2400B

INTELLIGENT COMPUTER FRONT END

System Guide

FLUKE®

2400B

INTELLIGENT COMPUTER FRONT END

System Guide

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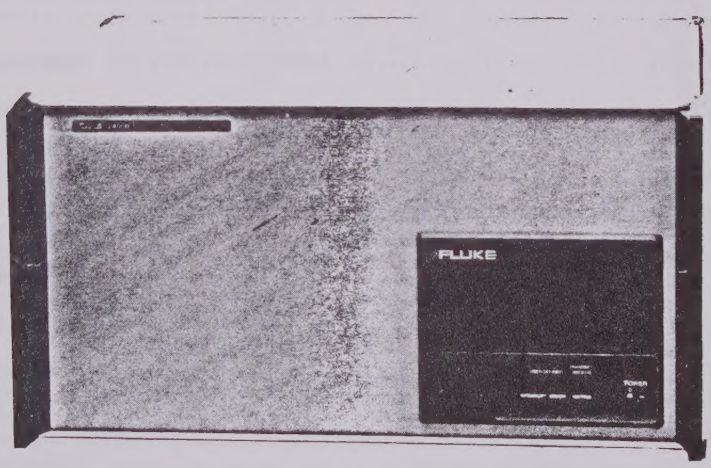

2400B Intelligent Computer Front End

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INTRODUCTION

The 2400B System Guide provides an all-inclusive guide to 2400B installation. This manual can be used as a general measurement and control system description, as a specific installation and set-up guide, or as a quick reference for interconnections and settings.

Installation involves both physical and electrical connection of the 2400B mainframe. In addition, options, accessories, and extender chassis available for the 2400B allow for a wide range of applications. The options constitute circuit cards that, when inserted into the mainframe, become an integral part of the 2400B. Each option defines a specific measurement or control function. Accessories allow for various exterior connections. The extender chassis permit the installation of additional option assemblies.

ORGANIZATION

Section 1	How to Use This Manual Describes System Guide organization, use, and conventions.
Section 2	Measurement and Control Systems Explains the roles played by measurement and control system components, communications within the system, and elements of the programming language used.
Section 3	Installation Describes physical and electrical installation of the 2400B mainframe. Installation for options and accessories is dealt with in succeeding sections.
Section 4	Accessories and Extender Chassis Provides instruction in the installation and use of accessories that enhance 2400B functions. Also describes the Extender Chassis, which house additional option assemblies.
Section 5	Serial Interface Option General and specific information about the use of RS-232, RS-422, and current loop interfacing arrangements.
Section 6	IEEE-488 Interface Option Discusses the IEEE-488 Bus and describes set-up and use of the IEEE-488 interface.
Section 7	Analog Input Options Separately documents the installation and use of each analog input option.
Section 8	Digital Input Options Installation and use of each digital input option is separately described.
Section 9	Output Options Each option that provides an output from the 2400B is described.

Section 10 Installation Quick Reference

Provides an abbreviated reference for option pin assignments and switch settings. Pin assignments for IEEE-488 and RS-232-C connectors are also given.

Section 11 Appendices

There are five appendices as follows:

Appendix A Fluke Sales and Service Centers
Appendix B 2400B Specifications
Appendix C 2400B Error Messages
Appendix D ASCII and IEEE-488 Codes
Appendix E Glossary

HOW TO USE THE MANUAL SET

2400B Programming Guide

This manual describes the 2400B programming language from top to bottom. A beginning programmer could use the Programming Guide as a complete course in using the 2400B in a measurement and control system. A more experienced programmer would only need parts of this manual for orientation.

2400B Programming Reference

This manual suits a wide range of needs. Users can "drop into" the manual at a point appropriate for their level of knowledge and experience. And, at any time, the manual can be used as a reference for a brief (or full) description, a diagrammed presentation of a programming step, or a programming example.

2400B System Guide

The System Guide shows you how to connect the 2400B in a measurement and control system. This manual emphasizes installation; the Programming Guide and Programming Reference document the system's use.

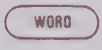
2400B Service Manual

This manual deals with service, troubleshooting and repair. Parts lists are also included.

SYNTAX DIAGRAMS

What They Are and How to Use Them

A syntax diagram serves as programming language "shorthand". It graphically represents construction of a valid command or statement in the 2400B programming language. Syntax diagrams are frequently used in this manual. Becoming familiar with them now will add to their usefulness later.



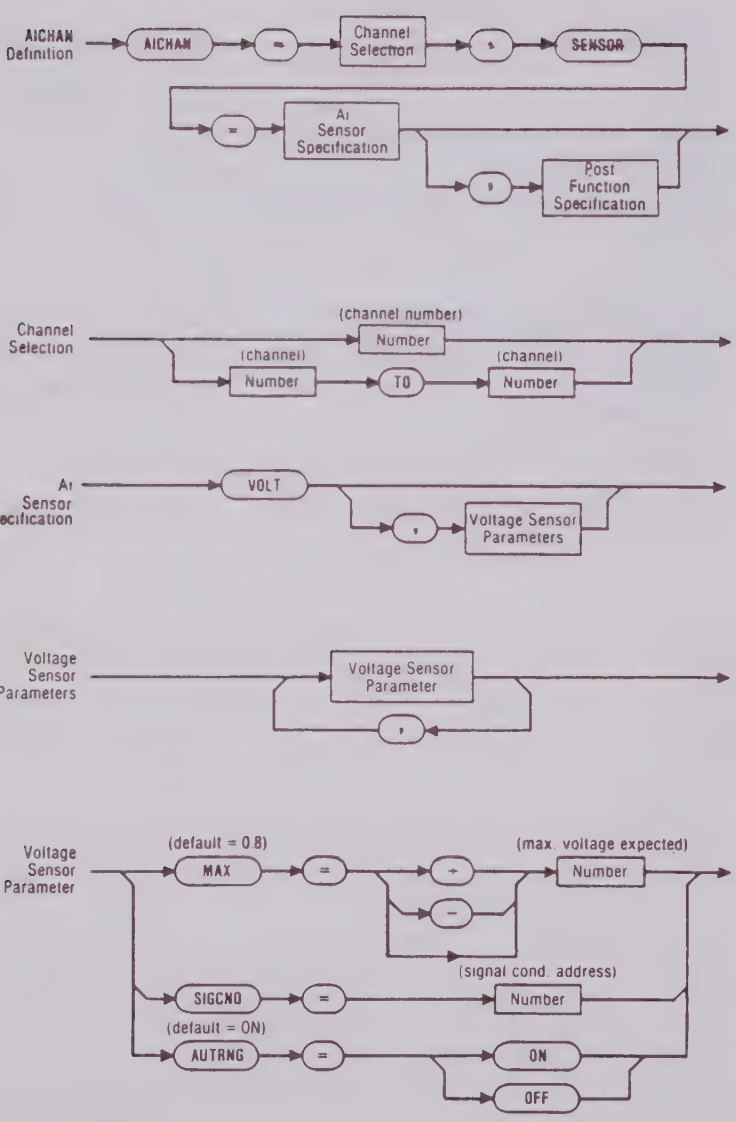
The WORD (all capital letters) in an oval must be entered exactly as it is shown.

The Words (initial capital letters) in a box signify that more information must be supplied. If another syntax diagram is specified, that construction must be followed at this point.

Words (all lower case) in parentheses are not part of the diagram, but do provide further explanation of the nearest block or path. A default value may also be indicated.

Sample Syntax Diagram

From the left, any path that goes in the direction of the arrows is a legitimate sequence for the parts of a statement. The sample syntax diagram on the next page shows the correct syntax for an analog input channel definition.


AICHAN Definition
AICHAN
=
Channel Selection
,
SENSOR
=
Ai Sensor Specification
,
Post Function Specification
Channel Selection
(channel number)
Number
(channel)
Number
TO
(channel)
Number
Ai Sensor Specification
VOLT
,
Voltage Sensor Parameters
Voltage Sensor Parameters
Voltage Sensor Parameter
,
Voltage Sensor Parameter
(default = 0.8)
MAX
=
+
−
(max. voltage expected)
Number
(signal cond. address)
SIGCND
=
Number
(default = ON)
AUTRNG
=
ON
OFF

- A syntax diagram may specify use of other syntax diagrams. In this example, three other syntax diagrams (Channel Selection, AI Sensor Specifications, and Voltage Sensor Parameters) are required to construct the AICHAN definition.

- Where indicated, commas must be used as separators within the programming string.

- Default values are set when no other value has been specified. For example, if no Voltage Sensor Parameters are set, the default values shown in parentheses are used. Default values are a MAX of 0.8 and autoranging ON.

- An optional Post Function Definition can also be specified.

- The wording in each oval is very specific and must be followed exactly.

- Explanations (in parentheses) further define the Number boxes.

- The voltage sensor parameter construction can be used three times, once each for MAX, SIGCND, and AUTRNG. Parameters are separated with commas.

- An example of a valid analog input channel definition:

```
AICHAN=11,SENSOR=VOLT,MAX=-0.5;
```

NOTATION CONVENTIONS

The 2400B uses literal notation for programming entries. Therefore, programming examples found in this manual are presented exactly as they should be entered the host computer keyboard.

Some notation conventions are used to identify and differentiate a programming entry. Parts of these conventions are not actually used in the entry.

(xxx) Indicates a required input of your choice. Parentheses are included as part of the syntax. For example, ENABLE (channel number) requires the input of a channel number on which interrupts are to be enabled. "ENABLE(10)=1!" would enable channel 10 interrupt.

<xxx> Means enter an ASCII string of the type indicated by the item or phrase in the brackets. Do not enter the brackets. For example, "<cr>" means "enter the carriage return character". Or, "<array variable name>" means "enter the legal name of an array."

XXX Means to type the input exactly as shown.

SECTION 2

MEASUREMENT AND CONTROL SYSTEMS

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INTRODUCTION

A measurement and control system makes decisions based on the measured process values, nominal constants and user inputs. These decisions determine what action, if any, the system should take to affect the physical process. The control action can be as simple as turning on an indicator light when something is too hot, or as complex as proportional, integral and derivative (PID) real-time control in a continuous process.

The 2400B is called an Intelligent Computer Front End because it is the interface between your computer and the process to be measured and controlled. It is the link between your computer and your sensors and actuators. Such a link is necessary because general purpose computers tend not to deal well with the physical environment. Being an intelligent (i.e. able to perform computing tasks) instrument, the 2400B can reduce raw measurement data to more a usable form before presenting it to your host computer. The 2400B can make all of the decisions necessary to control the process, freeing your computer to perform the storage, data processing and supervisory tasks for which it is well-suited, while measurement and control procedures are left to the 2400B.

Even an experienced programmer may find the 2400B a bit complicated: the instrument monitors and controls dozens of real world activities through a structure of bus commands, stored program statements and measurement and control functions. These are all entered into the host computer and sent to the 2400B embedded in the host command language. Actually, all of this is extremely efficient. But programming in two languages (that of the host computer and that of the 2400B) is a concept different from those encountered in other programming activities.

Read this section. The two-language concept is clearly explained. Relationships among measurement and control system hardware are defined. New terminology is explained. This section serves as an essential first step for all levels of programming experience.

HOW THE SYSTEM FITS TOGETHER

By itself, the 2400B can do nothing. But its descriptive name "intelligent computer front end" suggests its immense capability when it is used in a measurement and control system. Such a system and its various parts are explained in the following paragraphs. In the actual number of components and connections, the system can be quite complex. In the number of essential concepts and functions, the system is as simple as shown in Figure 2-1.

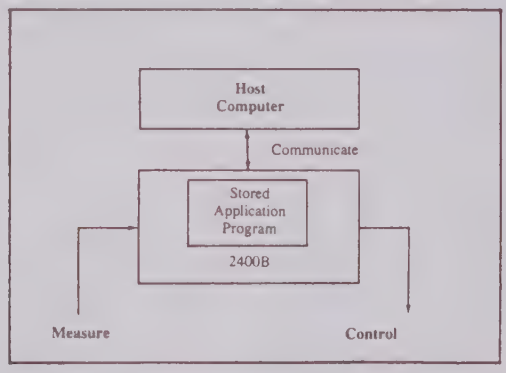

Figure 2-1. A Measurement and Control System

A measurement and control system both listens and talks to an industrial environment. It can measure or monitor the operation of devices placed in an industrial process. It can analyze and display this measurement information. And it can modify the operation of the process being measured. Numerous combinations of measurement devices may be used in a variety of industrial processes. Whatever combination is used, the system must perform the following five functions to accomplish the measurement and control task:

- DATA COLLECTION: Monitor a variety of physical quantities and devices at numerous measurement points.
- DATA REDUCTION: Process and convert the measurement information into a useful form.
- ANALYSIS AND DECISION-MAKING: Make decisions based on the measurement data acquired.
- INDICATION AND CONTROL: Take action based upon an analysis, or indicate the results of analysis.
- USER INTERFACE: The operator must be able to define the system function and obtain the results of system operation.

The five functions listed are not usually implemented by a single device. If several devices are used to form a measurement and control system, the nature of the system is largely determined by the way these functions are distributed.

Figure 2-2 illustrates the structure of the measurement and control system for which the 2400B was designed. This system contains three main elements: a host device (computer), an instrumentation device (the 2400B), and a communication bus that links the two. The five necessary functions are distributed between the host device and the instrumentation device. The communication link connects the host device to the measurement and control instrumentation.

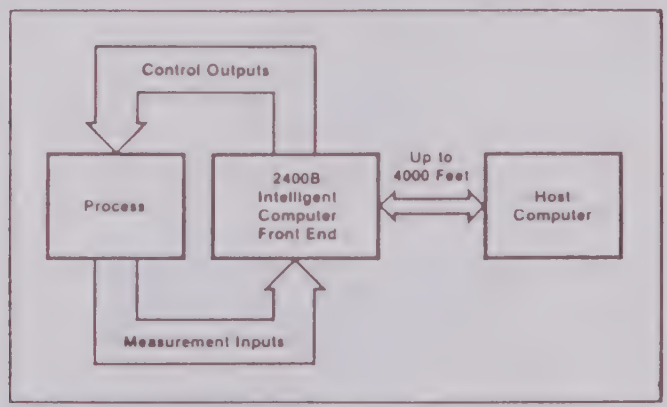

Figure 2-2. System Elements

The Environment

The most important part of the system is the environment. As seen by a monitoring instrument, the environment may range in complexity from the on/off conditions of a single process to the continual, multiple condition changes found in a large-scale manufacturing facility. The information generated by the environment may be in analog (continuous) or digital (on/off) form. And it may be necessary to monitor a bewildering variety of conditions; temperature, voltage, pressure, resistance, current, and relay conditions are common.

The environment may also require outside control based on the monitored conditions. Again, the environment can present a wide range of complexity. The control action can be as simple as turning on an indicator light when something is too hot or as complex as proportional, integral, and derivative (PID) real time control in a continuous process. Dozens of control actions may be required.

The measurement and control environment can certainly be a demanding place. Dozens of conditions may require continual measurement. Based on these measurements, control decisions may be required at any time. The environment can easily command the full attention of the rest of the measurement and control system.

The Intelligent Computer Front End (2400B)

The 2400B is the link between the measurement and control environment and the host computer. Primarily, it must collect all the diverse forms of data available from the environment. Secondly, where necessary, it must reduce the data to a usable format. Finally, it must make decisions based on the data collected. In all three of these tasks, the 2400B may or may not require assistance or supervision from the host computer. In fact, it is intelligent enough to measure and control some or all of the processes in the environment. When this capability is employed, the host computer is free to perform other tasks.

The Communications Link (IEEE-488 or Serial)

The communications link is the path between the host computer and a 2400B. It is the route along which all bus commands are sent to the 2400B. It is also the primary route for the 2400B to communicate back to the host computer and the programmer. A choice of IEEE-488 or serial communication format is allowed.

The Host Computer

The host computer provides an information exchange between the system operator or programmer and the 2400B. The host computer is necessary when initially programming the 2400B, when changing the stored program, or when requesting data from the system. At other times, the 2400B independently performs the measurement and control functions, leaving the host computer free. The host can also be used to store large quantities of data, to provide a means for an operator to interact with the system, and to supervise 2400B activity.

Other System Components

Other devices may be necessary to perform a particular function. For example, a line printer or tape recorder could be connected to the host computer to provide an auxiliary measurement record. The Fluke 1780A InfoTouch (TM) Display is commonly used as a video display which also provides limited control input back to the 2400B. If you really want to get carried away, you can develop almost any sort of custom data display and/or recording scheme, using the 2400B auxiliary output ports.

Operation

Just as the capabilities and use of other system components must be understood, the person doing the programming must be well informed about the 2400B's operation. The programmer must know the language used by the host computer, the language used by the intelligent computer front end, and the relationship between the two. Knowledge of system interconnections and the environment being measured and controlled is also important.

A Typical System Configuration

A typical measurement and control system configuration is comprised of a 2400B Intelligent Computer Front End in conjunction with a Fluke 1722A Instrument Controller. This controller is a small computer that can be used on a desk top or in a rack mount. The 1722A contains one IEEE-488 bus interface, one RS-232-C serial interface, a keyboard, a mini-floppy disk drive, and a touch-sense display screen. The programming languages available with the 1722A include both interpreted and compiled BASIC, FORTRAN and Assembler. The commands necessary to communicate with the 2400B are a part of the BASIC language and are implemented with standard library calls in the FORTRAN package.

The 2400B does operate with other host computers. However, the host must have certain capabilities to communicate with the 2400B. A summary of requisite capabilities is presented in this guide. The examples and applications presented in the 2400B Programming Guide in 1722A BASIC may need some translation into the language of the the host computer being used. This task is usually straight-forward, especially when the translation is between dialects of the same language.

Roles Played by the 2400B

Once the 2400B system concept is understood, it becomes possible to look at the specific roles played by the 2400B. The 2400B is at the center of the measurement and control system and interacts with the other components (and with itself) in a variety of ways.

Primarily, the 2400B serves as an interface between the measurement and control environment and devices providing inputs and outputs (host computer, printer, recorder, etc.).

The 2400B also serves as a signal converter. The measurements taken in the environment may range from voltage checks to temperature monitoring to on/off condition indications. But the 2400B measurement and control hardware can only input and output electrical values: signals that can be measured in volts or amperes. The 2400B can, however, through its internal programming, convert these signals into numbers that correspond to the physical entity that is represented by the electrical value.

For example, to measure a temperature, the 2400B must be connected to a sensor which converts temperature to voltage. The 2400B can then measure the voltage provided by the sensor. This voltage measurement can then be converted to a number which is expressed in temperature units.

The 2400B is an intelligent computer front end, which helps increase the efficiency of the measurement and control system. During normal operation, this distributed intelligence can accommodate all interactions with the measurement and control environment and the peripheral devices. Host computer time is not required. The host computer is normally needed to provide the 2400B with operating instructions, to allow the operator access to the process, to collect and store or analyze data generated by the 2400B, and to supervise and modify 2400B activity.

HOW INFORMATION IS EXCHANGED WITHIN THE SYSTEM

The Exchange Structure

A basic measurement and control system will have a process, a 2400B, a host computer and, at some point, an operator. A system could also include a printer or other data-receiving device. Thus, we have three essential interfaces: the operator interface; the host interface; and the process interface. Each of these is described more fully in the following paragraphs.

Operator Interface

An operator interface is where a human interacts with the measurement and control system. Inputs from the operator consist of switches, potentiometers, or other devices which the operator can control directly. These devices are sensed by the 2400B as inputs.

Outputs to the operator consist of warning lights or audible alarms, meter deflection, or messages transmitted through a printer or display device.

Host Interface

The host interface is the communication between the host and the 2400B. Throughout this manual, "host interface" refers to the hardware connection between these two instruments. The interface itself can be the Serial Interface (Option 2400B-001) or the IEEE-488 Interface (Option 2400B-002). Communications over this interface directly control the operation of the 2400B, which, in turn, controls the process.

Process Interface

This interface is comprised of the signals exchanged between the 2400B and the actual process under control. Signals which the 2400B receives from the process are called "measurement inputs". Signals sent back to the process from the 2400B are called "control outputs".

Languages

HOST LANGUAGE

The host is required only to send and receive data strings to and from the 2400B. Any language used by the host is acceptable to the 2400B, as long as that language is capable of reading and writing ASCII strings to the communications link.

2400B LANGUAGE

The messages sent by the host to the 2400B are ASCII strings in the 2400B language. The 2400B operates with a BASIC-like language which is called the 2400B Command Language. It uses functions such as CALL, PRINT and IF which are quite similar to like-named functions in BASIC. The

language does have some quirks, however, which reflect the specific purposes of the language.

The 2400B recognizes two classes of commands, called "Bus Commands" and "Stored Program Statements". Bus commands are executed immediately upon receipt from the host. Stored program statements, on the other hand, are executed as a group, after first being stored in the 2400B memory. Actual execution of a stored program does not begin until a "START" bus command is received from the host. The entire contents of the stored program memory is executed, one statement at a time.

Bus commands allow the operator to obtain an immediate response from the system. This is done by entering a command at the host and sending it to the 2400B.

Stored programs are another feature of the 2400B. An entire process monitor and control procedure can be programmed into the 2400B and left to operate by itself. This frees the host instrument for other tasks.

Measurement and control functions are elements of the 2400B language which perform the actual interface tasks with the process. Measurement functions control the input hardware for monitoring the process, while control functions operate the control output hardware.

A HOST/2400B SYSTEM

The Fluke 2452 MCS is an example of a complete measurement and control system. The 2452 MCS includes the 2400B Intelligent Computer Front End and the 1722A Instrument Controller, connected to each other with either the IEEE-488 parallel bus or the RS-232-C serial communications link. Bus commands and stored programs are entered at the 1722A keyboard, and sent to the 2400B over the bus. Various option cards in the 2400B monitor the measurement inputs and provide the control outputs, as dictated by the measurement and control functions in the stored program.

SUMMARY

The 2400B Intelligent Computer Front End is an interface between a host computer and a physical process. The 2400B performs data collection, data reduction, and control tasks with minimal supervision from the host computer.

A complete system will include the process, one or more 2400Bs, a host computer and an operator. Auxiliary devices can also be included to take information directly from the 2400B.

Instructions written in the 2400B command language are embedded as literal strings within commands written in the host's language. The 2400B language itself is somewhat similar to BASIC, but has added features which allow it to perform its functions more effectively in the context of process measurement and control systems. The host communicates directly with the 2400B via bus commands, which are executed immediately by the 2400B. Stored programs are down-loaded from the host to the 2400B and executed independently of the host. Measurement and control functions operate the hardware options in the 2400B chassis to monitor measurement inputs and to generate control outputs.

SYSTEM GUIDE

The rest of this manual explains how to connect and configure a measurement and control system using the various options available to perform your desired functions. The remaining sections are as follows:

Section 3 Installation

Describes physical and electrical installation of the 2400B mainframe. Installation for options and accessories is dealt with in succeeding sections.

Section 4 Accessories and Extender Chassis

Provides instruction in the installation and use of accessories that enhance 2400B functions. Also describes the Extender Chassis, which house additional option assemblies.

Section 5 Serial Interface Option

General and specific information about the use of RS-232, RS-422, and current loop interfacing arrangements.

Section 6 IEEE-488 Interface Option

Discusses the IEEE-488 Bus and describes set-up and use of the IEEE-488 interface.

Section 7 Analog Input Options

Separately documents the installation and use of each analog input option.

Section 8 Digital Input Options

Installation and use of each digital input option is separately described.

Section 9 Output Options

Each option that provides an output from the 2400B is described.

Section 10 Installation Quick Reference

Provides an abbreviated reference for option pin assignments and switch settings. Pin assignments for IEEE-488 and RS-232-C connectors are also given.

Section 11 Appendices

There are five appendices as follows:

Appendix A Fluke Sales and Service Centers
Appendix B 2400B Specifications
Appendix C 2400B Error Messages
Appendix D ASCII and IEEE-488 Codes
Appendix E Glossary

SECTION 3

INSTALLATION

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INTRODUCTION

This section contains unpacking, service, installation, and operator maintenance information. It is recommended that you read the following information before attempting to install and operate the 2400B Intelligent Computer Front End. Should difficulties arise during installation, contact your nearest John Fluke Sales Representative or the factory at the following address:

John Fluke Manufacturing Co., Inc.
P. O. Box C9090
Everett, Washington 98206
U.S.A.
Telephone: (206) 342-6300

Tables listing sales representatives and factory service centers are found in Section 11, Appendix A.

SHIPPING

The 2400B Intelligent Computer Front End mainframe is packaged with foam end caps in a cardboard shipping container. This container also contains a smaller box holding the manuals and line cord.

Upon receipt of the instrument, inspect the shipping container to reveal any possible shipping damage. Special instructions for inspection and claims are included on the shipping container.

If it is necessary to reship the instrument, use the original container. If the original container is not available, a new one can be obtained from the John Fluke Manufacturing Co., Inc. upon request.

SERVICE INFORMATION

The Model 2400B Intelligent Computer Front End is warranted for a period of one year after delivery to the original purchaser. The WARRANTY is located on the back of the title page of this System Guide.

Factory authorized calibration and service for Fluke products is available at many locations worldwide. A complete list of Fluke Service Centers is included in Section 11, Appendix A. If requested, an estimate will be provided to the customer before repair work is begun on an instrument after the warranty period expires.

UNPACKING

Remove the rest of the contents of the box that contained this book. Take inventory to make sure you received everything on the following unpacking checklist.

Unpacking Checklist

1. 2400B System Guide
2. 2400B Programming Guide
3. 2400B Programming Reference
4. 2400B Service Manual
5. Line cord

Slide the 2400B out of the shipping container. Pull the foam end caps off the cabinet. The instrument is shipped with the ordered options installed in the chassis. Make sure each option is securely mounted in the chassis.

PHYSICAL LAYOUT

The 2400B mainframe includes a power supply, motherboard, and on the rear panel are two RS-232-C output ports (Print Ports 0 and 1), an air filter, line cord plug, and fuses. Inside the chassis are two reserved pcb slots for the Option 2400A-109 A/D Converter, a communication option slot for the IEEE-488 or Serial Interfaces, and six Input/Output option slots. Various input connector options are available to mount on scanner options (an input connector is shown in Figure 3-2). Figure 3-1 shows a front view of the 2400B and Figure 3-2 shows a rear view. Specifications for the 2400B are in Section 11, Appendix B.

The mainframe must be ordered with one of two available host computer interfaces. The interface allows loading of the user's application program through a host computer using a variety of communication techniques (look under the heading Selecting the Interface Option).

The 2400B's language resides in 64 K bytes of EPROM memory space. The user's application program is loaded into and uses up to 28 K bytes of RAM memory space. User-designed application programs may also be burned into EPROM memory, making the 2400B a stand-alone system without the need of a host computer to download the program.

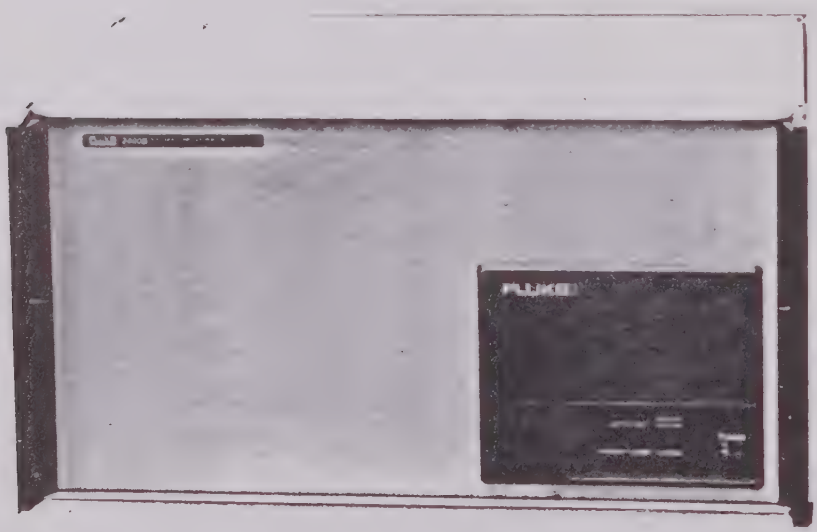

Figure 3-1. 2400B Front View

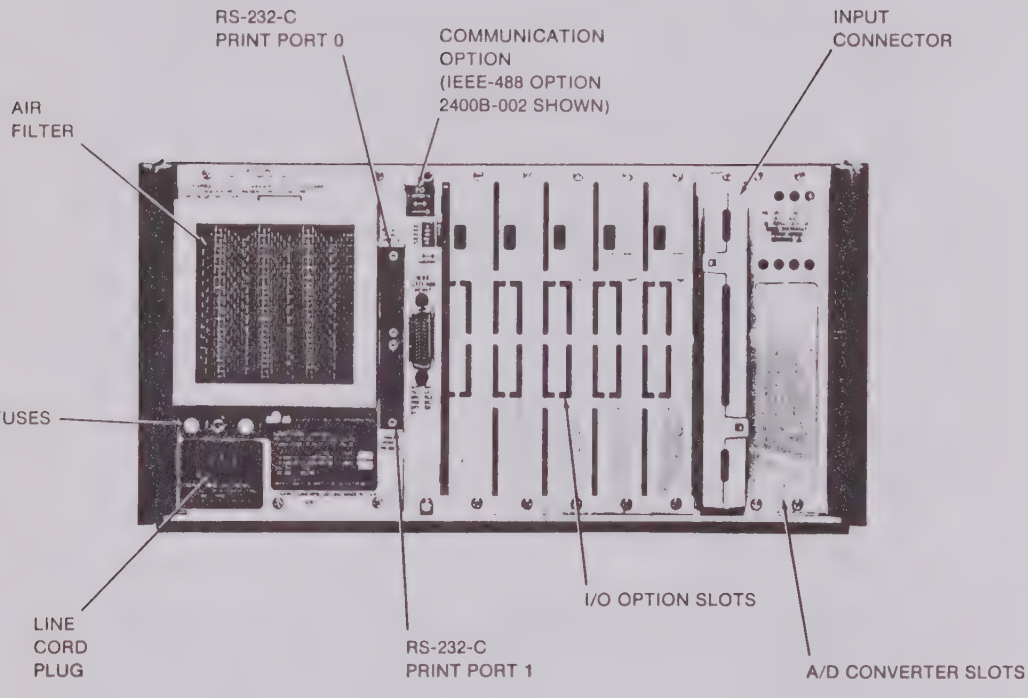

Figure 3-2. 2400B Rear View

The Front Panel of the 2400B has a power switch and six light-emitting diode (LED) indicators. The indicators and their functions are as follows:

USER DEFINED

Software controlled to turn off or on at the user's discretion by Bus Command or Stored Program Statement.

TRANSMIT/RECEIVE

Lights when the 2400B is transmitting characters to or receiving characters from the host computer.

POWER

Lights after the 2400B has performed its power-up initialization, and remains lit until the power is turned off.

WAITING

Lights when the 2400B is in a wait condition.

ERROR

Lights when the 2400B detects a system error or an error in the bus command or stored program statement being executed.

INTERRUPT

When using the IEEE-488 Interface (Option 2400B-002), the INTERRUPT indicator lights when the 2400B encounters an SRQ statement in a stored program or detects an error when ERROR SRQ ON is activated. The INTERRUPT indicator is turned off when an IEEE-488 Serial Poll is performed by the bus controller.

When using the Serial Interface (Option 2400B-001), the INTERRUPT indicator lights when the 2400B executes a PRINT #2 statement. The INTERRUPT indicator is turned off when the host computer sends the 2400B a SPOLL! command.

INSTALLING THE 2400B

Selecting a Location

After unpacking and inspecting the 2400B, select an appropriate location for installation. Case dimensions for the 2400B Intelligent Computer Front End are: 21 cm high x 46 cm wide x 38 cm long (8.27 in x 18.11 in x 14.96 in). The 2400B chassis may be placed in any location with adequate clearance for ventilation and rear-panel cabling. Check to make sure that the location for the 2400B meets the environmental requirements listed in the Specifications.

The 2400B may be situated on a table or other horizontal surface, or may be adapted to fit into an electronic instrument rack. Rack mounting instructions follow, and racks and rack-mounting kits available from Fluke are described in Section 4, Accessories and Extender Chassis.

Rack-Mounting the 2400B

The 2400B Intelligent Computer Front End may be rack-mounted in a standard 19-inch electronic equipment rack. Rack-mounting requires one of two mounting accessories: Accessory Y2053 Rack Mount Kit With 24-Inch Slides or Accessory Y2054 Rack Mount Kit. Instructions for rack-mounting the 2400B using both kits follows. Instructions are also packed with each kit (they are included here for your convenience).

RACK-MOUNTING WITHOUT SLIDES

To mount the 2400B Intelligent Computer Front End in a standard 19-inch electronic equipment rack without slides, use the Accessory Y2054 Rack Mounting Kit. Install the 2400B in the rack in the following way:

1. Remove the four molded plastic feet from the bottom cover of the instrument.

2. Peel the Fluke name plate decals from the front side-corners of the 2400B case.

3. Remove the front corner screws matching the hole pattern in the rack mounting ears (see Figure 3-3).

4. Fasten the rack mounting ears to the 2400B case using the six 8-32 x 7/8" screws provided in the rack mounting kit.

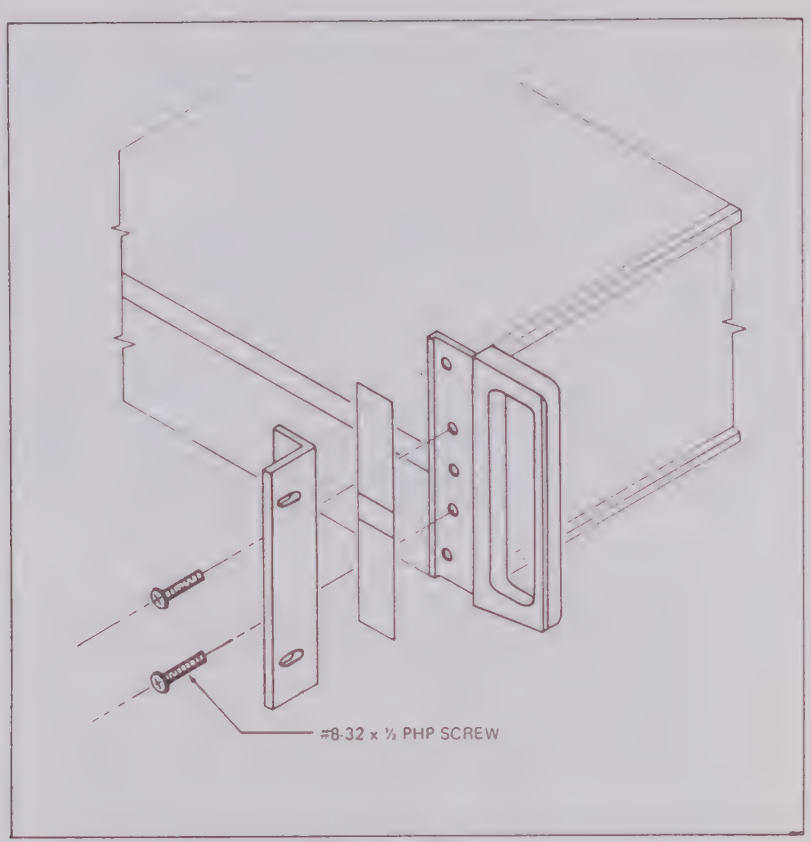

Figure 3-3. Mounting the Rack Ears

5. Install the Shelf Bracket in the equipment rack using the two 10-32 x 3/8" screws provided in the kit, on each of the four tabs.

6. Insert the 2400B chassis three-fourths of the way into the equipment rack, on top of the Shelf Brackets.

7. Attach the clip-nuts supplied in the kit to the front flange of the equipment rack, aligning them with the slotted holes of the rack mounting ears.

8. Slide the 2400B chassis all the way into the equipment rack and secure it with the machine screws provided in the kit.

RACK-MOUNTING WITH SLIDES

The 2400B Intelligent Computer Front End may be rack-mounted with slides in a standard 19-inch-wide by 24-inch deep electronic equipment rack using the Accessory Y2053 Rack Mount Kit With 24-Inch Slides. This mounting method allows the 2400B to be slid in and out of the rack for maintenance, calibration, or option installation and wiring. Use the following procedure to install the rack mounting ears and mount the 2400B Intelligent Computer Front End on slides in an equipment rack:

1. Remove the four molded plastic feet from the bottom cover of the instrument.

2. Peel the Fluke name plate decals from the front side-corners of the 2400B case.

3. Remove the front corner screws matching the hole pattern in the rack mounting ears (see Figure 3-3).

4. Fasten the rack mounting ears to the 2400B case using the six 8-32 x 7/8" screws provided in the rack mounting kit.

5. Using the screws supplied with the kit, attach Chassis Section (B) of the slide kit to each side of the case (refer to Figure 3-4).

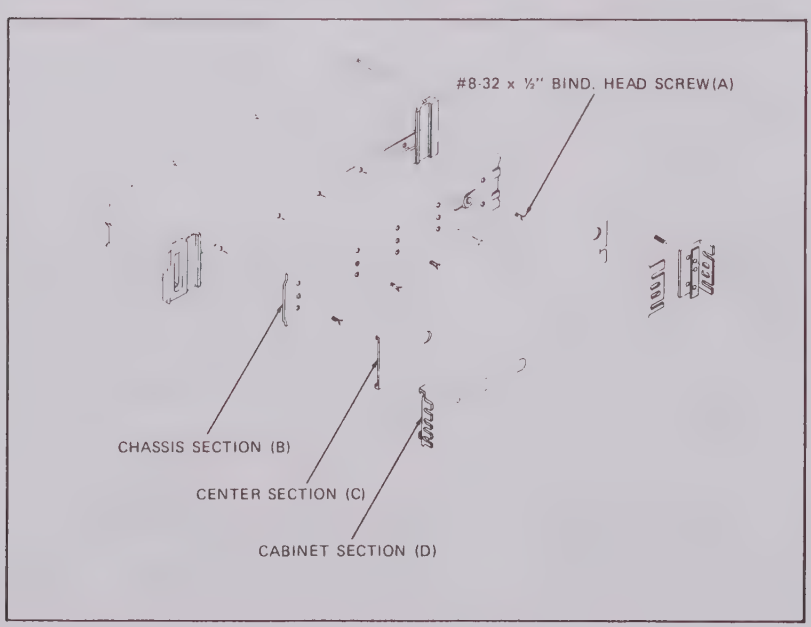

Figure 3-4. Mounting the Rack Slides

6. Install the cabinet section (D) and the center section (C) in the equipment rack.

7. Pull the center slide section out through the front of the equipment rack until it locks in the extended position.

8. Press the spring locks on the chassis section (B), and insert the chassis section in the center section (C).

9. Push the 2400B into the equipment rack, then pull it out to the extended position. The spring locks should limit slide travel.

Line Voltage Ranges

Two ac line voltage ranges are switch selectable within the 2400B: 120V ac and 240V ac. Line frequency may be either 50 Hz or 60 Hz, with 400 Hz operation available as a factory-installed selection. With the line voltage selection switch in the 120V ac position, line voltages between 90V and 132V ac are acceptable. With the switch in the 240V ac position, line voltages between 180V and 264V ac are acceptable.

The line voltage selection switch is located at the rear of the Transformer Assembly. Checking or changing the line voltage switch position requires removal of the fan cover. Refer to the Line Voltage Selection procedure in the Maintenance part of this section.

Selecting the Interface Option

Note

The 2400B is shipped with all ordered options installed, including the interface option. The following information relating to options is included for your reference.

The 2400B Intelligent Computer Front End is interfaced with a host computer (controller) using one of two interface options. They are the 2400B-001 Serial Interface Option and the 2400B-002 IEEE-488 Interface Option. The IEEE-488 Interface allows an IEEE-488-1978 compatible host to control and program the 2400B (See Section 6, IEEE-488 Interface Option for more information). This option is recommended when:

- Your host computer or controller has an IEEE-488 communications port.
- The 2400B will be less than 20 meters (66 feet) from the host.
- You are constructing a system in which the other instruments will communicate to the host through the IEEE-488 Bus.

If all three of these conditions are not true, the Serial Interface should be used instead. For a description of the Serial Interface, and information about its applications, see Section 6, Serial Interface Option.

The Serial Interface supports the following three separate interfaces: RS-232-C, RS-422, and 20-milliampere current loop. The Serial Interface allows communication between the host and the 2400B over dedicated lines of up to 4000 feet in length, or switched service over telephone lines. For further information about its operation and applications, see Section 5, Serial Interface Option.

Installing the Interface Option

Complete information on installing either the Serial Interface or the IEEE-488 Interface is in Section 5 or 6, respectively. Proceed to the appropriate section for information on the interface options.

Input/Output Option Installation

Options available for the 2400B system are discussed in Sections 7, 8, and 9. However, for a list of all options see the Table of Contents for Sections 7, 8, or 9. Although specific installation instructions for each option are given in the appropriate option section, information pertaining to the installation of all options follows.

SELECTING I/O OPTION SLOTS

The following option installation procedures are general guidelines for installing option assemblies in the 2400B Intelligent Computer Front End. Although the six option slots appear identical, it is best to choose the slot for each option systematically.

Most 2400B option assemblies may be installed in any of the six available option slots, however, there are exceptions. One exception is the High Performance A/D Converter, Option 2400A-009. This option has two pcb assemblies that must be installed in the two rightmost chassis slots (facing the rear of the chassis.)

For input scanner options, channel numbers are determined by the I/O option slot occupied by the scanner pcb. All other input and output option pcbs have switches that determine the channel numbers. The following conventions should be observed when installing option pcb assemblies in the 2400B (but some of these conventions may be changed if necessary to meet special requirements).

- I/O Extender Interface cards (Option 2402A-501) should be installed in the leftmost option slots.

- After the required interface options are installed, scanners and other I/O options may be installed in the remaining slots.

- Signal Conditioner Assemblies (Options 2400A-701 or 2400A-702) should be installed in the rightmost option slots.

- Scanner assemblies should be installed in the next available option slots to the right. Scanner channel numbers are determined by the slot occupied by the scanner. Channel numbers start with 0 in the rightmost slot.

- Scanner Extender Interface assemblies should be installed to the left of the scanner options to maintain sequential numbering of scanner channels without losing channel capacity.

- Remaining I/O option cards should be installed starting from the leftmost available slot. Option card numbers should be assigned sequentially as the cards are installed.

- Guidelines for scanner option installation apply to the 2401A Scanner Extender Chassis. Guidelines for I/O option installation apply to the 2402A I/O Extender.

OPTION INSTALLATION NOTES

To install option assemblies, first remove the 2400B rear panel. The rear panel, as shown in Figure 3-5, contains cutout sections that may be removed to accommodate various connector options. Figure 3-5 shows the rear panel section that must be removed for a scanner to be installed. Removing this section uncovers the chassis slot for the scanner option. Voltage Input, Current Input, and Thermocouple Input Connectors are housed in enclosures that also fit this rear-panel opening.

Two openings, as Figure 3-6 shows, may be used for other I/O options. The larger of the two openings accommodates connectors used to attach external devices to options, and the smaller opening (a permanent opening, not a cutout) provides access to option address switches.

Identification decals are supplied with each option. In Figure 3-6, the location marked B is for placement of the decals.

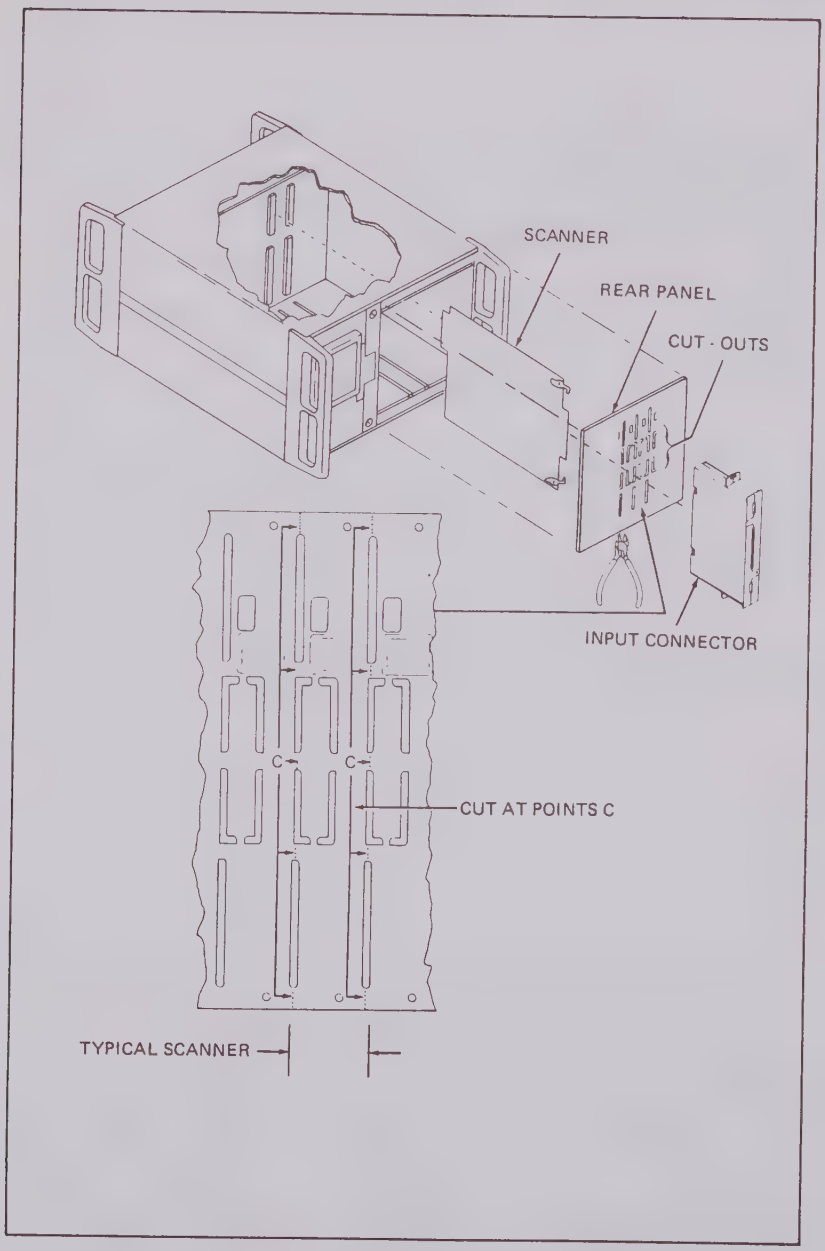

Figure 3-5. Scanner Slot

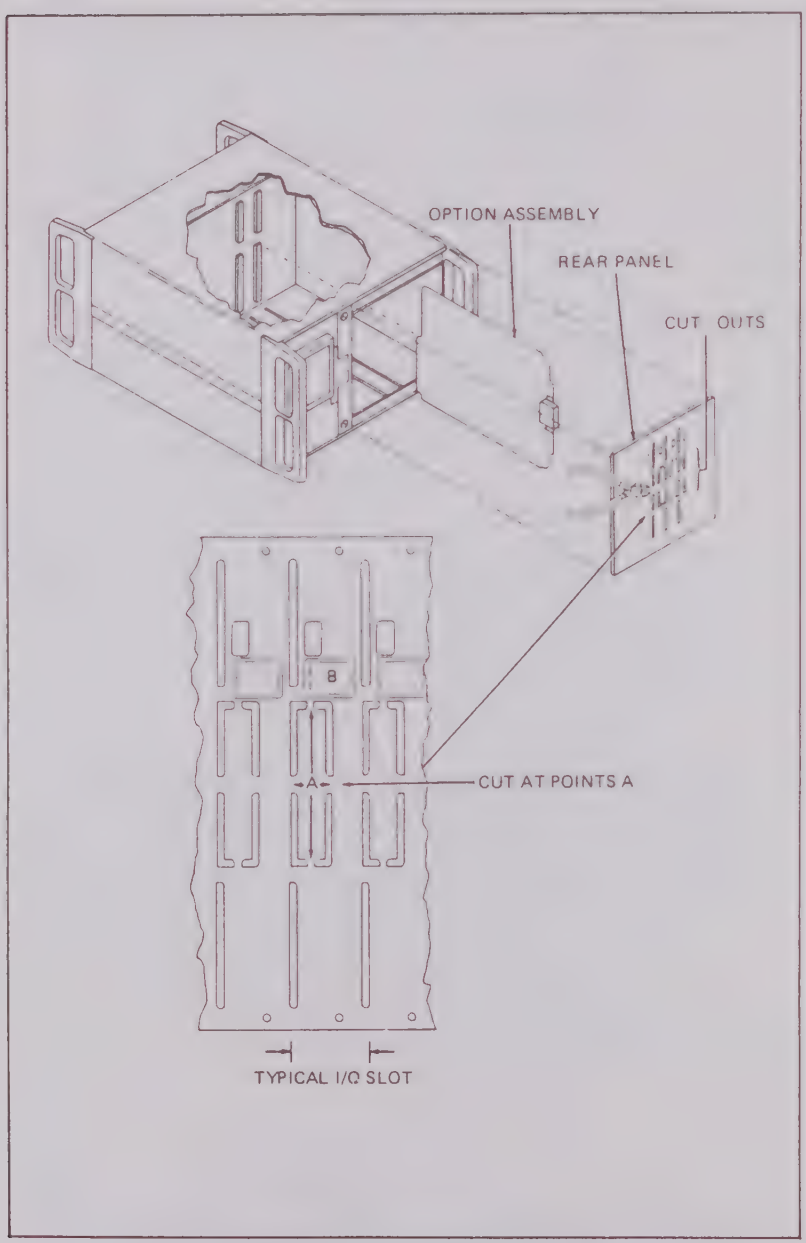

Figure 3-6. Option Slot

The RS-232-C Output Ports

INTRODUCTION TO RS-232-C

Electronics Industries Association (EIA) Standard RS-232-C provides the electronics industry with the ground rules necessary for independent manufacturers to design and produce both data terminal and data communication equipment that conforms to a common interface requirement. As a result, a data communication system can be formed by connecting an RS-232-C data terminal (such as the 2400B) to an RS-232-C data communication peripheral.

Presented here is an overview of the RS-232-C interface standard, intended to help the user understand enough background information to use the output ports on the 2400B. A more in-depth discussion of RS-232-C and serial data can be found in Section 5, Serial Interface Option.

Two RS-232-C Output Ports are located just to the left of the interface option on the real panel of the 2400B. These are provided for data to be output to peripherals such as printers and data loggers. They can also be used for certain data inputs, such as characters sent from a Fluke 1780A InfoTouch (TM) Display. The ports are called output ports because that is their primary function.

The user must be aware of the subtleties of serial binary data interchange to ensure that any two pieces of RS-232-C equipment will be compatible. For example, the two instruments must be compatible with respect to each of the following characteristics:

- Timing Format - Synchronous or Asynchronous.
- Transmission Mode - Simplex, half-duplex, or full duplex.
- Bit Rate (bits per second, or baud)
- Bits per Character - 5, 6, 7, or 8.
- Parity Bit - Odd, even, high, low, or not used.

Timing formats conforming to both synchronous and asynchronous operation are shown in Figure 3-7. In asynchronous operation each character is bracketed by both start and stop bits. These bits separate the characters and synchronize both the transmission and reception of data. When data is not being sent the data line is held high. In synchronous operation a sync character is sent prior to each data stream (a data stream usually consists of a block of characters). When the line is idle, a fill or sync character is continuously transmitted.

Transmission mode is an overall system requirement. It defines the communication ability of both instruments in the system configuration. Simplex indicates data transmission in one direction only. Half-duplex

permits two-way communications, but not simultaneously. Full duplex permits two-way communication simultaneously. An instrument capable of full duplex operation can be downgraded to simplex operation. However, the reverse is not possible without degrading the system capability.

Bit rate (also called baud rate) is usually selectable on the terminal device. If it is not, the manufacturer usually offers a choice of bit rates when the instrument is purchased.

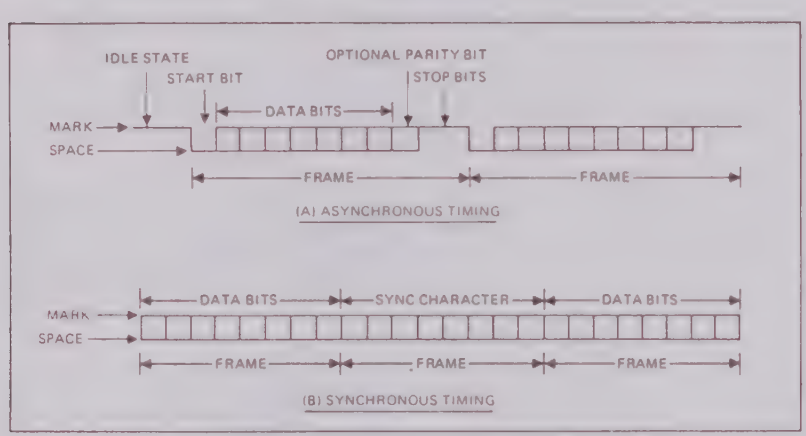

Figure 3-7. RS-232-C Timing Formats

Character format (bits per character and parity) is somewhat flexible between instruments. Investigate the requirements of both instruments before committing either to a system configuration.

RS-232-C OUTPUT PORT IMPLEMENTATION

The 2400B functions as a data terminal device as defined in the RS-232-C standard, and it operates in full-duplex transmission mode. It can send data in a variety operating parameters, but it can receive data only in a limited format (the output of the Fluke 1780A InfoTouch (TM) Display is an example of accepted data). The use of parity, baud rate, time-out, and transmit delay are all programmable through the host device (see the 2400B Programming Reference).

The character format used by the output ports is 7-bit ASCII code. The RS-232-C signal lines used by the output ports are listed with their pin assignments in Table 3-1. All pins not listed are left unconnected.

Table 3-1. RS-232-C Circuits Supported by the RS-232-C Output Ports

Pin Number	Circuit Name	Direction
2	BA Transmitted Data	From 2400B
3	BB Received Data	To 2400B
4	CA Request to Send	From 2400B
5	CB Clear to Send	To 2400B
6	CC Data Set Ready	To 2400B
7	AB Signal Ground	(Reference Ground)
11	unassigned -- always high	
12	SCF Secondary Rec. Line Signal Detect	To 2400B
19	SCA Secondary Request to Send	From 2400B
20	CD Data Terminal Ready	From 2400B

Note

When an RS-232-C signal is high, its logic state is true, and its voltage level is more positive than plus three volts. When the signal is low, its logic state is false, and its voltage level is more negative than minus three volts. All input signals are terminated in the true state if no external connection is made.

The functions of RS-232-C signals used by the 2400B output ports are:

- AB -- Signal Ground

  Signal Ground is the common reference for all the following interface signals.

- BA -- Transmitted Data

  Transmitted Data carries the stream of data bits generated by the 2400B to the output peripheral (printer, display, etc.).

- BB -- Received Data

  Received Data is the line that carries characters sent from a peripheral device such as the 1780A InfoTouch (TM) Display to the 2400B.

- CA -- Request to Send

  Request to Send is set high during power-up initialization.

- CB -- Clear to Send

  Clear to Send must be high to allow the 2400B to transmit data. When CB is low, the 2400B stops transmitting data.

- CC -- Data Set Ready

  Data Set Ready is sensed by the 2400B, but is not used to effect the operation of the 2400B.

- CD -- Data Terminal Ready

  Data Terminal Ready is always high.

- SCA -- Secondary Request to Send

  Secondary Request to Send is always high.

- SCF -- Secondary Received Line Signal Detect

  Secondary Received Line Signal Detect must be high to allow the 2400B to transmit data. When CB is low, the 2400B stops transmitting data.

Extender Chassis Installation

MODEL 2401A SCANNER EXTENDER CHASSIS

The analog input channel capacity of the 2400B can be increased from 60 to 1000 channels through the use of Model 2401A Scanner Extender chassis. Analog measurement in the 2400B is performed by the Analog-to-Digital (A/D) Converter, housed in the 2400B Intelligent Computer Front End. The A/D Converter is connected to an array of sensors through scanner option assemblies. If more than 60 sensors are required in a system, additional scanner option assemblies may be added, housed in one or more 2401A Scanner Extender chassis.

Scanner option assemblies mounted in 2401A Scanner Extender chassis are linked to the A/D Converter through a Scanner Interface assembly (Option 2401A-401) housed in the 2400B Mainframe. Up to ten 2401A Scanner Extender chassis may be connected in a 2400B system in either a daisy-chain or star configuration. Figure 3-8 illustrates the two different methods of connecting 2401A Scanner Extender chassis to the 2400B Intelligent Computer Front End. Only one 2401A-401 Scanner Interface is necessary in a daisy-chain network, but one interface is required for each two 2401A Extender chassis in a star network.

In a daisy-chain network, the first extender chassis is linked to the 2400B through the Scanner Interface assembly (Option 2401A-401). Each succeeding 2401A is connected to the previous 2401A by connecting the

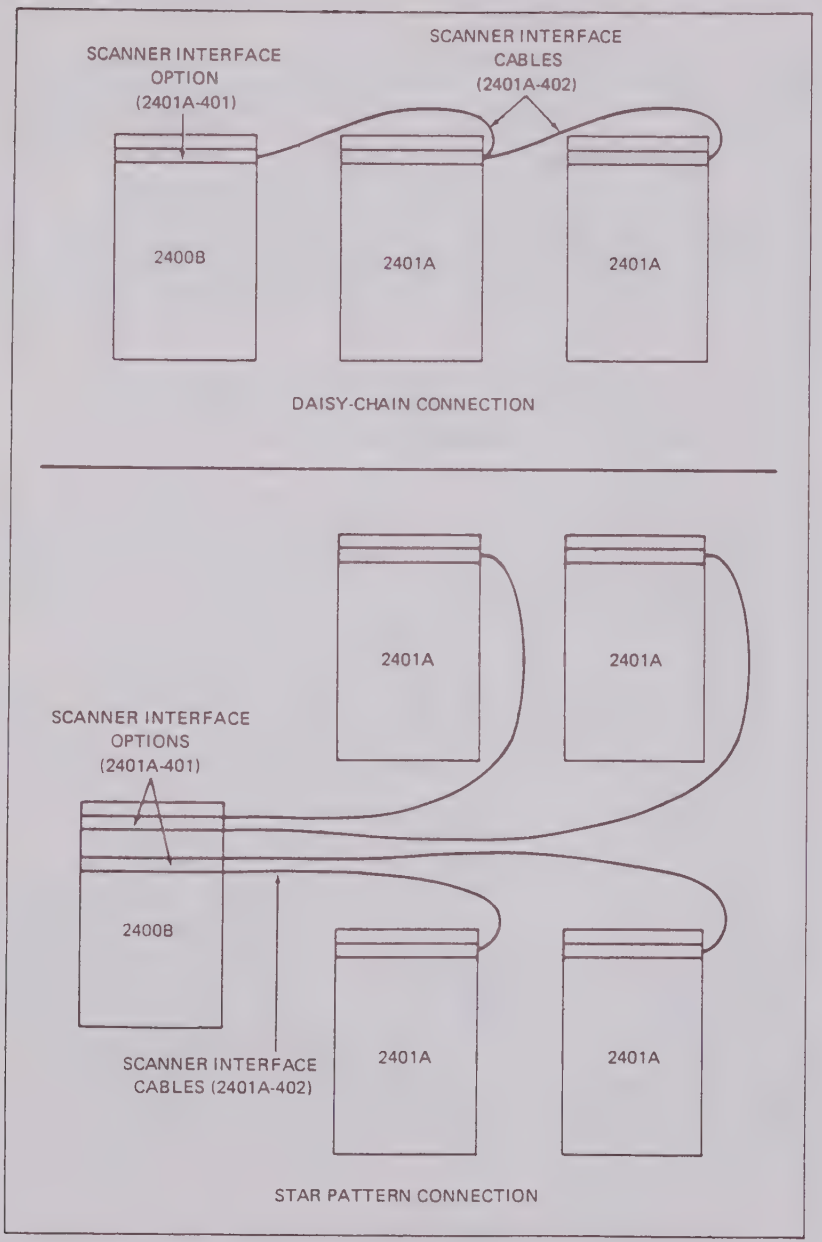

Figure 3-8. 2401A Extender Chassis Connection Configurations

Bank Select card connectors of both units using Scanner Interface Cables. A 2-meter interface cable, with connectors, is supplied with each 2401A. Additional cable is available in 1-meter increments (Option 2401A-402), and additional connectors are available for installation on the cable (Option 2401-403).

In a star network, all extender chassis are connected directly to the 2400B through Scanner Interface assemblies (Option 2401A-401) installed in the 2400B. Both configurations illustrated in Figure 3-8 require Scanner Interface Cables in addition to the Scanner Interface assemblies. In either configuration, the maximum distance between the 2400B and the 2401A is 76 meters (250 feet), with a limit of 152 meters (500 feet) in one system.

This has been an overview of the 2401A installation process. The instruction manual shipped with the 2401A extender chassis is the source of complete information.

MODEL 2402A I/O EXTENDER CHASSIS

Model 2402A I/O (Input/Output) Extender increases the capacity of the 2400B to house I/O option assemblies. A maximum of sixteen 2402A I/O Extenders may be used with one 2400B Intelligent Computer Front End to house up to 192 I/O option assemblies.

The 2402A I/O Extender chassis requires an I/O Extender Interface (Option 2402A-501) and an I/O Extender Interface Cable (Option 2402A-502) for connection to the 2400B. The interface assembly consists of a pcb and two I/O cable connectors. The interface mounts in the 2400B and is connected to the 2402A through the I/O Extender Interface Cable in a daisy-chain or star configuration as Figure 3-9 shows.

A 2400B Intelligent Computer Front End can support up to two 2402A-501 I/O Extender Interface Assemblies. Two I/O Extender Cables can be connected to each Interface Assembly, so the 2400B can be directly connected to four 2402A I/O Extenders. Each 2402A also has two connectors for I/O Extender Cables. The Extender Cable from the 2400B connects to one of them, and the other may be used to connect another 2402A in a daisy-chain fashion. Each of the two I/O Extender Interface Assemblies can support four 2402A I/O Extenders in series from each of its two connectors, provided that the total length of one cable series does not exceed 16 meters. Two meters of cable, with connectors, are supplied with each 2402A. Additional cable may be ordered in 9-meter increments, with connectors (Option 2402A-502). Thus the four cable connectors (on two I/O Extender Interface Assemblies) can support a total of sixteen 2402A I/O Extenders.

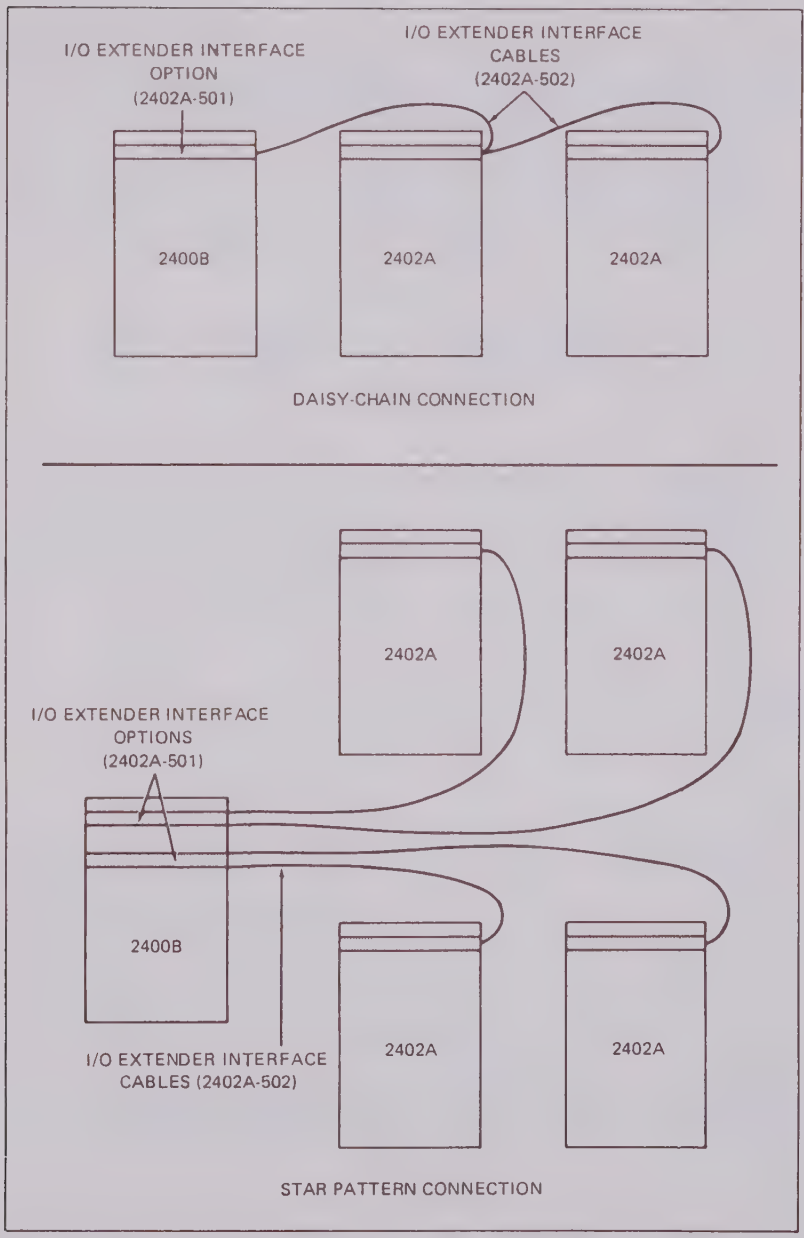

Figure 3-9. 2402A I/O Extender Chassis Connection Configurations

VERIFICATION TESTING

To verify correct installation and operation of the 2400B Intelligent Computer Front End, proceed to either Section 5 or 6, depending on which communication interface option you have. Those sections contain verification tests that should be completed after installation.

OPERATOR MAINTENANCE

Introduction

This part of the section describes all maintenance procedures the operator should perform. It includes line voltage selection, fuse replacement, and fan filter cleaning instructions. Detailed service and troubleshooting information, including theory of operation and calibration information, is contained in the 2400B Service Manual. Service involving other procedures than those covered here must be referred to qualified maintenance personnel.

WARNING

LETHAL VOLTAGES MAY BE PRESENT WITHIN THE 2400B AND ON SOME OPTION CARDS. DO NOT REMOVE THE INSTRUMENT COVERS UNLESS YOU ARE QUALIFIED TO DO SO.

Line Voltage Selection

Two ac line voltages are switch selectable within the 2400B: 120V ac and 240V ac. The line voltage select switch is located at the rear of the Transformer Assembly. Checking or changing the line voltage switch position requires removing the rear fan panel. To remove the rear fan panel, use the following procedure:

1. Remove the ac line cord and measurement circuits from the instrument.
2. Remove the four screws that hold the rear fan panel to the chassis.
3. Loosen the captive screw located below the fan and above the fuses.
4. Remove the rear fan panel.
5. Reverse the four preceding steps to install the rear fan panel after checking or changing the line voltage switch setting.

After removing the rear fan panel, use the following procedure to select the desired line voltage:

1. Locate the input line voltage switch at the back of the Transformer Assembly.
2. Move the slide switch so that the desired voltage setting shows.
3. Check the line voltage fuses to make sure they are the correct size for the input voltage selected. Refer to the fuse replacement procedure.

Fuse Replacement

Caution

For continued fire protection, replace the fuse only with another 250V fuse of the indicated rating.

Different fuse ratings are required for each of the two input line voltage settings. The correct fuse sizes for each setting are shown on a decal on the 2400B rear panel. Use the following procedure to check or replace the line voltage fuses:

1. Disconnect the ac line power cord.
2. Locate the line voltage fuses. They are just below the fan filter cover on the rear panel of the 2400B.
3. Use a screwdriver to turn each fuse cap 1/8 turn counter-clockwise.
4. Pull the fuse cap and fuse out of the fuse holder and check or replace the fuse.
5. To reinstall the fuse, place the fuse in the fuse cap, insert the fuse and cap in the fuse holder, then push the fuse cap in and turn it 1/8 turn clockwise.

Fan Filter Cleaning

The filter mounted over the fan opening on the 2400B rear panel must be cleaned every 30 days under normal operating conditions. In unusually dusty environments, more frequent cleaning may be necessary. Use the following procedure to clean the fan filter:

1. Locate the fan filter on the rear panel of the 2400B.
2. Loosen the captive screw at the bottom of the fan filter frame.
3. Pull the filter frame and filter out and down to remove them.
4. Wash the filter element in a solution of warm water and mild detergent. Dry it thoroughly before reinstalling.
5. Place the filter in the filter cover, then insert the tab at the top of the filter cover in the slot on the rear panel of the 2400B.
6. Tighten the captive screw at the bottom of the fan filter frame.
7. Reinstall the 2400B in the system.

General Cleaning

Caution

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They may damage plastic materials used in the instrument.

Clean the instrument periodically to remove dust, grease and other contamination. The case may be cleaned using a soft cloth dampened in a mild solution of detergent and water. Printed circuit board surfaces may be cleaned using clean, dry air at low pressure (<20 psi). If grease is present on the pcbs, spray with anhydrous alcohol and remove grime with clean, dry air at low pressure.

CONCLUSION

This section of the System Guide provides installation hints and general procedures for hardware set-up. Since the 2400B Intelligent Computer Front End is such a versatile, option-oriented instrument, specific information on installation of options is not found in this section. Sections 5 and 6 serve as guides covering the two communication interface options. Sections 7, 8, and 9 cover all hardware aspects of the remaining I/O options (except extender chassis options, which are found in Section 4, Accessories and Extender Chassis). Information on operating the system with the various options can be found in the 2400B Programming Guide and the 2400B Programming Reference.

SECTION 4

ACCESSORIES AND EXTENDER CHASSIS

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INTRODUCTION

This section describes accessories and extender chassis (and options for the extender chassis) that expand 2400B capabilities. It can be a guide to help select accessories needed to complete a 2400B system, or a reference source after the accessories have been purchased. Interface Options, Analog Input Options, Digital Input Options, and Output Options that meet specific system requirements are described in their own sections.

The 2401A Instruction Manual and the 2402A Instruction Manual contain detailed information regarding installation and operation of those models. Manuals are supplied with the extender chassis when purchased.

CABLE ACCESSORIES

IEEE-488 Interface Cables

When using the IEEE-488 Interface Option 2400B-002, an IEEE-488 cable is used to connect the 2400B to the host. IEEE-488 cables, with IEEE-488 connectors attached is available from Fluke as the following accessories:

- Accessory Y8001 -- One-meter IEEE-488 Cable
- Accessory Y8002 -- Two-meter IEEE-488 Cable
- Accessory Y8003 -- Four meter IEEE-488 Cable

RS-232-C Interface Cables

When using the RS-232-C Interface on the 2400B-001 Serial Interface, these cables may be used to connect the 2400B to Data Communication Equipment (DCE). An example of DCE is a modem. RS-232-C cables complete with connectors are available from Fluke as the following accessories:

- Accessory Y1707 -- Two-meter RS-232-C Cable
- Accessory Y1708 -- Ten-meter RS-232-C Cable

RS-232-C Null-Modem Cables

An RS-232-C Null-Modem Cable is used when the 2400B and the host computer are direct-connected without modems. The Null-Modem Cable takes the place of two modems when a direct-connect network is desired.

These RS-232-C Null-Modem Cables are complete with connectors and are available from Fluke as the following accessories:

- Accessory Y1702 -- Two-meter RS-232-C Null-Modem Cable
- Accessory Y1703 -- Four-meter RS-232-C Null-Modem Cable
- Accessory Y1705 -- One-foot RS-232-C Null-Modem Cable

The Y1705 is intended to be used in conjunction with a standard RS-232-C cable.

CONNECTORS

Option 2400B-604 15-Pin D-Type Connector Pair

Option 2400B-604 is a pair of 15-pin D-type connectors for use in cabling a 20-milliampere current loop or RS-422 communication network.

Note

One connector is provided with the Serial Interface Option.

Accessory Y2055 15-Conductor Multi-Connector

Accessory Y2055 15-Conductor Multi-Connector is a three-way connector assembly necessary in a multipoint RS-422 2400B network. It is comprised of three subminiature 15-pin D-type connectors (two on one end and one on the other end of a short cable) with all signal lines connected in parallel. One Y2055 15-Conductor Multi-Connector is required for each 2400B mainframe except the last one in the in an RS-422 multipoint system.

RACK MOUNTING ACCESSORIES

Y2053 Rack Slide Kit

This kit contains all necessary hardware, including rack ears, to mount the 2400B or an accessory chassis in a standard 19-inch rack with a depth of 24 inches. This mounting arrangement allows the user to pull the instrument out of the rack on slides, without having to dismantle mounts, to gain access to the back. Rack Slide Kit assembly instructions are found in Section 3, Installation, and are packed with the kit.

Y2054 Rack Mount Kit

This kit is for those who wish to mount the 2400B or an accessory chassis in a standard 19-inch-wide by 24-inch-deep rack in a fixed arrangement. Rack ears, mounting brackets, instructions, and fasteners are included. Rack Mount Kit assembly instructions are found in Section 3, Installation, and are packed with the kit.

Y2452 Rack

The Y2452 Rack is used to create a complete Model 2452 Measurement and Control System from a 2400B and a Fluke 1722A Instrument Controller. The rack includes a divider and air baffle for improved cooling, a rear access door, and two drawers; one for the keyboard and the other for storage. A lockable door covers both drawers. The Y2452 Rack also includes a 2452MCS series instruction manual set and associated software. The Y2452 Rack is 13 rack units high.

Note

One rack unit is 1.75 inches (4.45 cm) high. The 2400B, 2401A, and 2402A are all five rack units high. The 1722A Controller is three rack units high.

The dimensions of the Y2452 Rack are 29 inches H (73.6 cm H), 24 inches W (61 cm W), 27 5/8 inches D (70.4 cm D), and it weighs 208 lbs. (95 kg).

A24-89 Rack

The A24-89 Rack is the same rack as the Y2452 without the divider or drawers. This rack allows the mounting of two 2400 series extender chassis. It can be bolted underneath or above the Y2452 Rack and has a lockable rear access door. The A24-89 Rack has the same dimensions as the Y2452 Rack and weighs 195 lbs. (89 kg).

A24-75 Rack

The A24-75 Rack is 38 rack units high, and comes with caster wheels and can be leveled using four built-in screw-down glide feet. It also has two anti-tilt feet on swing-out arms for use when pulling the instrument out of the rack. The rear door contains a polyurethane foam cable-mounting panel so the door can be opened without disturbing cable runs. The dimensions of the A24-75 Rack is 77.25 inches H (196.2 cm high), 24 inches W (61 cm W), and 27 5/8 inches D (70.4 cm D), and it weighs 280 lbs. (127 kg.).

Filler Panels

Unused rack spaced can be filled with the following filler panel accessories:

- o A24-81 One Rack Unit
- o A24-82 Two Rack Units
- o A24-83 Three Rack Units
- o A24-84 Four Rack Units
- o A24-85 Five Rack Units
- o A24-79 Six Rack Units
- o A24-80 Seven Rack Units

Custom Racking Service

Fluke will quote on the service of installing 2400B Systems in a rack or racks and functionally testing the assembled units. Also, racks other than the ones above are available upon request.

ACCESSORY A24-8 RELAY OUTPUT MODULE

The A24-8 Relay Output Module contains 32 relays with 6A contact ratings. The module is controlled by the 2400A-301 Status Output assembly, and power to drive the relay coils is supplied by a power supply in the A24-8 Relay Output Module.

ACCESSORY A24-65 EPROM PROGRAMMING SERVICE

The A24-65 EPROM Programming Service includes the service of burning a user's 2400B language program into EPROM, and the EPROM chips. The program must be supplied to Fluke as a BASIC comment, remark or data file on a 1720A or 1722A Series floppy disk. Ask a Fluke Sales Representative for more information about the A24-65 EPROM service.

EXTENDER CHASSIS

Model 2401A Scanner Extender Chassis

The 2400B alone can scan 60 input channels. This number can be increased to a maximum of 1000 by using 2401A Scanner Extender Chassis and related options. The extender chassis is the same size and shape as the 2400B, but has no indicators on the front panel.

The analog measurement section of the 2400B is centered around the Analog-to-Digital (A/D) Converter, which is connected through analog scanners to an array of sensors. To add more analog input channels to a system, more Scanner Option (Option 2400A-101, 2400A-115, or 2400A-117) assemblies must be used. The 2400A-101 High Performance Scanner and the 2400A-115 Four-Wire Scanner assemblies each have ten channels. The 2400A-117 Six-Wire Scanner assembly has five channels. Up to ten scanner cards can be installed in each 2401A Scanner Extender Chassis, and up to ten 2401A Extender Chassis can be supported by one 2400B Intelligent Computer Front End.

The link between the A/D Converter and each 2401A Extender Chassis is maintained through a Scanner Extender Interface assembly (option 2401A-401) and Scanner Extender Cable (Option 2401A-402). Configuration of the Scanner Extenders using this interface is flexible; additional chassis and cables may be connected in a parallel (star) configuration, or in series (daisy chain) configuration. (See Figure 3-8 in the Installation section). More information on options 2401A-401 and 2401A-402 follows.

OPTION 2401A-401 SCANNER EXTENDER INTERFACE

The Scanner Extender Interface allows the user to link scanner assemblies installed in the 2401A to the A/D Converter installed in the 2400B. The Scanner Extenter Interface is a pcb assembly that resides in the 2400B chassis. One or two strings of 2401A Scanner Extenders may be connected to the 2400B in a daisy-chain configuration using only one 2401A-401. In the star configuration, one 2401A-401 is required for each two 2401A Scanner Extenders. Communication is through the Scanner Extender Cable (Option 2401A-402).

OPTION 2401A-402 SCANNER EXTENDER CABLE

The Scanner Interface Cable is a 35-conductor shielded cable used to carry analog signals, digital control signals, and power between a 2401A Scanner Extender chassis and the chassis (either 2400B or 2403A) housing the A/D Converter. The -402 cable and two 50-pin, subminiature "D" connectors are supplied with the 2401A. Additional cable (2401A-402) and connectors (2401A-403) are available from John Fluke Manufacturing Company, Incorporated. The two connectors mate with the Scanner Interface Option (2401A-401). Cable length is specified by the customer, in 1 foot increments, up to a maximum of 250 feet.

OPTION 2401A-403 I/O EXTENDER INTERFACE CONNECTORS

The 2401A I/O Extender Chassis comes with a one-meter cable complete with connectors. For systems requiring more than one meter of 2400B Interface Cable, a longer length of cable (Accessory 2401A-402) and two connectors (Accessory 2401A-403) may be ordered. Fluke solders the connectors and tests the cable before shipping the assembled unit.

Model 2402A I/O Extender Chassis

The Input/Output channel capacity of the 2400B can be increased by using 2402A I/O Extender Chassis. Input/Output options that can be installed in the 2402A include:

- Digital Input (Option 2400A-103)
- Status Input (Option 2400A-104)
- Counter/Totalizer Input (Option 2400A-113)
- Interrupt Input (Option 2400A-114)
- Status Output (Option 2400A-301)
- Current/Voltage Analog Output (Option 2400A-302)
- Resistance Output (Options 2400A-305 and 2400A-306)
- Stepper Motor Controller (Option 2400A-307)

Up to 16 2402A I/O Extenders may be added to a 2400B Intelligent Computer Front End System, providing space for 192 I/O option assemblies. Each 2402A Extender contains its own power supply and slots for 12 I/O option assemblies. The extender chassis is the same size and shape as the 2400B, but has no indicators on the front panel. Several 2402A I/O Extenders may be connected in star or daisy chain configuration (see Figure 3-9 in the Installation Section).

The 2402A I/O Extender is linked to the 2400B by an I/O Extender Cable (Option 2402A-502) and an I/O Extender Interface (Option 2402A-501). More information on Options 2402A-501 and 2402A-502 follows.

OPTION 2402A-501 I/O EXTENDER INTERFACE

The I/O Extender Interface Assembly is a required option for communication between the 2400B and 2402A. The option is a printed circuit board assembly that resides in the 2400B chassis and provides communication with the 2402A I/O Extender through the 2402A-502 I/O Extender Cable option.

The 2400B Measurement and Control system can support up to two I/O Extender Interfaces, and each in turn can support two I/O Extender cables. Therefore, a maximum of four cables can branch out from the 2400B. The 2402A Extender chassis provides two connectors. One connector receives the I/O Extender Cable from the 2400B chassis and the other is used to connect additional 2402A chassis. This "daisy-chain" configuration can accommodate up to four I/O Extenders connected in sequence, provided that the total length of a given "cable leg" does not exceed 15 meters. Thus, the four cable legs (each connecting four 2402A chassis) allow a total of 16 I/O Extenders (holding up to 192 I/O assemblies) in a 2400B system.

OPTION 2402A-502 I/O EXTENDER INTERFACE CABLE

The I/O Extender Cable serves as the communication link between the 2400B and 2402A. The cable is a 50-conductor flat cable with a wire-mesh ground plane to improve immunity from environmental interference and to reduce crosstalk. A 50-contact connector is provided on each end to mate with the headers provided on the I/O Extender Interface (Option 2402A-501) and the 2402A chassis. A two meter cable is supplied with each 2402A; a nine-meter cable (2402A-502), with connectors attached, is available as an option for the 2402A.

SECTION 5

SERIAL INTERFACE OPTION

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INTRODUCTION

General

The Serial Interface (Option 2400B-001) allows you to access the 2400B through a host computer using a variety of asynchronous bit-serial digital communication techniques. The Serial Interface supports the following three separate interfaces on one assembly: RS-232-C, RS-422, and 20-milliampere current loop. The position of a jumper on the pcb (printed circuit board) assembly selects one of these three interfaces. Switch positions select bit rate (baud), character format, message transfer protocol, modem control, and multipoint address. The jumper and all five switches must be set prior to installation. Specifications for the 2400B-001 Serial Interface are listed in Table 5-1.

Physical Layout

The 2400B-001 Serial Interface is a single pcb assembly with a rear panel strip at one end. A male RS-232-C 25-pin D-type connector is located in the middle of the rear panel strip, and a female 15-pin D-type connector (for use with RS-422 and 20-milliampere current loop) is below it. At the top of the rear panel strip is a 10-segment led (light-emitting diode) panel indicator. Figure 5-1 shows the rear panel strip of the Serial Interface.

Table 5-1. 2400B-001 Serial Interface Specifications

General Specifications:	
Timing format	Asynchronous
Character format	Bit-Serial, ASCII, one start bit
Data bits	Seven or eight, switch selectable
Stop bits	One or two, switch selectable
Baud rates	50, 110, 300, 600, 1200, 2400, 4800, 9600, 19200 bits per second
Parity bit	None, even, odd, zero, or one
Transmission protocols	Simple terminal, simple terminal with flow control, simple terminal with flow control and timeout, blocked, and blocked with block check character
Electrical interfaces	RS-232-C, RS-422, and 20-milliampere current loop
RS-232-C Interface Specifications:	
Input levels	Mark = false = -3 to -15 volts dc Space = true = +3 to +15 volts dc
Input signals	BB - Received Data CB - Clear to Send CC - Data Set Ready CF - Received Line Signal Detect SCF - Secondary Received Line Signal Detect CE - Ring Indicator
Output signals	BA - Transmitted Data CA - Request to Send SCA - Secondary Request to Send CD - Data Terminal Ready
Modem control	Full-duplex, full-duplex with auto-answer, half-duplex, half-duplex with reverse channel
LED status indicators	Request To Send, Clear To Send, Data Set Ready, Data Terminal Ready
Maximum cable distance per RS-232 standard - 50 feet	

Table 5-1. 2400B-001 Serial Interface Specifications (cont.)

Connector	Interface: 25-pin male subminiature D-type Cable: 25-pin female subminiature D-type
RS-422 Interface Specifications:	
Mark state input threshold voltage	R+ > R- by 200mv or more
Space state input threshold voltage	R+ < R- by 200mv or more
Maximum number of 2400B's per system	10
Maximum cable distance	4000 feet
Maximum baud rate	19200 bits per second
Connector	Interface: 15-pin female subminiature D-type Cable: 15-pin male subminiature D-type
20-Milliampere Current Loop Interface Specifications:	
Isolation	Optical isolation of passive receiver and transmitter
Current sources	Two sources, non-isolated, wiring selected on connector
Transmitter voltage drop	1.0 volts dc
Current source compliance voltage	15 volts dc
Transmitter power-down state	Passively shorted by normally-closed relay
Transmitter compliance voltage	25 volts dc
Receiver voltage drop	1.5 volts dc
Maximum number of 2400B's per system	10
Maximum loop distance	5000 feet
Maximum baud rate	4800 bits per second
Connector	Interface: 15-pin female subminiature D-type Cable: 15-pin male subminiature D-type

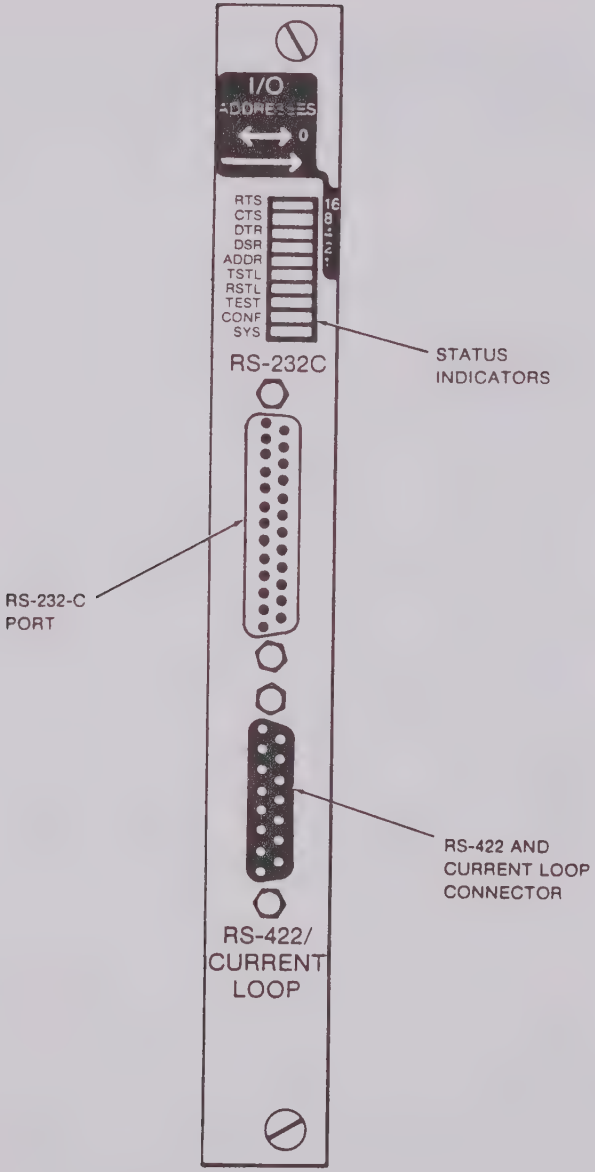

Figure 5-1. Serial Interface Rear Panel Strip

Status Indicators

The led segments indicate the status of important interface signals and conditions. The top four indicators show the status of modem control signals (the led is lit when the signal is on). The next three indicators show the state of the interface, and the bottom three are self-test error indicators. Specifically, their meanings are as follows:

RTS -- Lights when RS-232-C modem control signal Request to Send is in the high state.

CTS -- Lights when RS-232-C modem control signal Clear to Send is in the high state.

DTR -- Lights when the RS-232 modem control signal Data Terminal Ready is in the high state.

DSR -- Lights when the RS-232 modem control signal Data Set Ready is in the high state.

ADDR -- In a multipoint network, lights when the interface has been addressed (always on in a two-point system).

TSTL -- Lights if the interface is stalled in the output mode.

RSTL -- Lights if the interface is stalled in the input mode.

TEST -- Lights at power-up until Serial Interface self tests are complete, and remains lit only if the interface detects a ROM (Read Only Memory) or RAM (Random Access Memory) test error.

CONF -- Lights at power-up, but remains lit only if the interface configuration switches are set in an invalid combination.

SYS -- Remains lit after power-up if the 2400B CPU (Central Processing Unit) cannot communicate with the Serial Interface.

Serial Interfacing Using Modems

Using the RS-232-C interface with appropriate modems (devices that transmit and receive bit-serial data) connected to the telephone service, a 2400B equipped with the Serial Interface may be programmed and run from great distances. In a similar way, several 2400B Intelligent Computer Front Ends can be accessed by one host computer. Switched service (telephone line) operation is possible only using the RS-232-C interface in conjunction with modems.

Serial Interfacing Using Dedicated Lines

Serial interfacing using the 2400B-001 is also possible over runs of certain lengths without using modems. Using the RS-232-C interface, with a distance of less than 50 feet between the 2400B and the host, a hard-wired direct connection can be made using a Null-Modem Cable (Fluke Accessories Y1702, Y1703, or Y1705 which duplicate the effect of two modems). In systems with runs up to 4000 feet, hard-wired connections can be made in an RS-422 system using twisted-pair cable and Accessory Y2055 Fluke 15-Conductor Multi-Connectors. See Table 5-2 for maximum allowable cable lengths for each bit rate used by the Serial Interface.

Table 5-2. Maximum Cable Lengths (In Feet) For Each Bit Rate

Bit Rate (baud)	RS-232-C	Current Loop	RS-422
50	50	5000	4000
110	50	5000	4000
300	50	5000	4000
600	50	4000	4000
1200	50	2500	4000
2400	50	1000	4000
4800	50	500	4000
9600	50	(do not use)	4000
19200	50	(do not use)	4000

Current Loop Capability

The 20-milliampere current loop interface is available on the Serial Interface for those who wish to retro-fit a 2400B Intelligent Computer Front End into an older data communication system using current loop communication. The 20 milliampere current loop is used almost exclusively for teletype writer, and paper tape punch/reader interfaces. Communication using current loop in a direct-connect system is possible over runs of 500 to 5000 feet, depending on bit rate. See Table 5-2, Maximum Cable Lengths For Given Bit Rates. A summary of the possible communication system configurations using the Serial Interface follows.

Configuration Summary

With the Serial Interface, the 2400B can be remotely accessed by a host computer in the following types of networks:

- RS-232-C direct-connect, two-point
- RS-232-C with modems over a dedicated line, two-point
- RS-232-C with auto-answer modems (switched service)
- RS-422 direct-connect, two-point
- RS-422 direct-connect, multipoint (up to ten 2400B's)
- Twenty-milliampere current loop, two-point
- Twenty-milliampere current loop, multipoint (up to ten 2400B's)

Where to Go From Here

To use the interface in the way best suited to your application, it is important to understand the nature of serial data and how it is transferred. The following section includes an introduction to serial data, a description of the character format choices available, and an overview of the sequence of events that have to occur to accomplish data transfer. If you are experienced with serial communication, and know exactly how you want to configure the Serial Interface, you may want to skip some of this information and go to Interface Configuration and Installation.

Serial Data

WHAT IS SERIAL DATA?

Digital information represented as groups of bits (high and low states, representing ones and zeros), sent over one line, one bit at a time, is called bit serial data.

TIMING AND SPEED

Serial data can be transmitted in two different timing formats, synchronous and asynchronous. Synchronous data, also called message framed data, has start and stop characters marking the beginning and end of each message block. Individual characters in the message are sent one after the other, without any special bits separating them. Asynchronous data is also called character framed data, because is has start and stop bits separating each character, so each character is transmitted as an independent unit. The 2400B-001 Serial Interface operates using asynchronous timing exclusively.

Serial data speed is expressed in bits per second, or baud. Although baud means the rate of actual state changes per second, it is often used interchangeably with bit rate. The 2400B-001 Serial Interface can send and receive data at all bit rates listed in Table 5-1.

CHARACTER FORMAT

Information is sent to and from the 2400B-001 Serial Interface in the form of ASCII (American Standard Code for Information Interchange) coded characters. Figure 5-2 shows the format of a single asynchronous serial character. Each character begins with one start bit (low), then seven or eight data bits (the ASCII character), then an optional parity bit, and finally one or two stop bits (high). This character format applies to all three interface types.

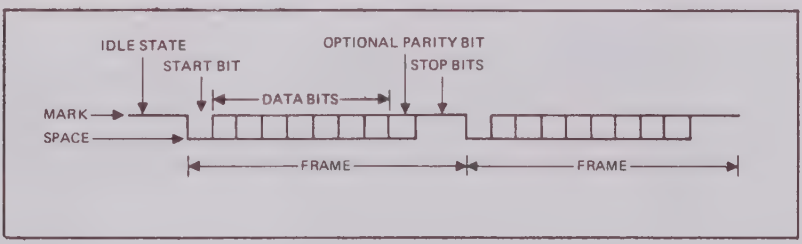

Figure 5-2. An Asynchronous Serial Character

Reception of the start bit tells the receiving station that the next seven (or eight, depending on a switch setting) bits represent an ASCII coded character (transmitted least significant bit first). The start bit is always a single low bit (zero).

The stop bit tells the receiving station that it has reached the end of the character. The stop bit is high, and so is the idle state of the line. A stop bit may be immediately followed by the start bit for the next character, or may just return the line to its idle state (if it belongs to the last character to be transmitted). You can select a stop bit of one or two bits in length, to match the Serial Interface to the requirements of various host computers and interfaces. CHARACTER FORMAT switch (S3) setting instructions are found under the heading, Configuring Your Interface.

PARITY

The parity bit follows the seven or eight data bits of the ASCII-coded character. The parity bit is used as an error detection device, and can be configured in five different ways on the Serial Interface:

- Parity Off

  If the Serial Interface is set to parity off, the interface does not transmit a parity bit, and does not expect to receive one. In the case of parity off, the stop bit immediately follows the last data bit of the character.

- Even Parity

  Even parity means that the parity bit, when mathematically added to the binary digits of the ASCII-coded character, yields an even number.

- Odd Parity

  Odd parity means that the parity bit, when mathematically added to the binary digits of the ASCII-coded character, yields an odd number.

- Parity 1, Parity 0

  When set to parity 1 or 0, the Serial Interface sets the parity bit to a 1 or 0, respectively, when transmitting. Parity 1 or 0 is used only when the 2400B is transmitting, for the benefit of devices that require fixed parity bits. Unlike the other parity settings, the Serial Interface ignores parity bits it receives when in these settings.

Instructions on setting the parity switch segments of the CHARACTER FORMAT switch (S3) are under the heading, Configuring Your Interface.

Data Transfer Event Sequence

The information in this section is an introduction to serial data communication using the 2400B-001 Serial Interface. Detailed instructions regarding system circuit connections, interface configuration, and operation are found in later sections. It is recommended that you read this introductory section before you attempt to configure and run the Serial Interface.

CIRCUIT CONNECTION

The first step in data transfer between two or more computers (one host and one or more 2400B's) involves the electrical circuit connection. The connection can be either direct-connect (over a dedicated hard-wired line) or switched service (over a telephone line). The network can be two-point, with just the host computer and the 2400B, or multipoint (also called multi-drop), with one host computer and several 2400B's.

The RS-232-C interface can be used in either switched service or direct-connect networks. However, the 20-milliampere current loop and RS-422 interfaces can only be direct-connected.

Using RS-232-C, a direct-connect circuit is made with a Null-Modem Cable. In systems using RS-422, a direct-connect circuit is made with twisted-pair shielded cable. The maximum acceptable cable runs for direct-connect systems at various bit rates are listed in Table 5-2.

Multipoint switched-service networks with auto-answer modems (RS-232-C only), are really switched two-point networks, as each modem remains disconnected from the circuit until its own telephone number is dialed. Connection occurs in a switched-service system (RS-232-C interface) with auto-answer modems when the line attached to the modem rings. This happens as follows:

1. The modem at the host end dials the number for a particular 2400B to establish a link with that Intelligent Computer Front End.

2. The line at the 2400B end rings, and the 2400B-001 interface detects signal CE (Ring Indicator) high.

3. The Serial Interface responds by asserting CD (Data Terminal Ready) high. This tells the auto-answer modem to answer the line and a connection is established.

This is an overview of the RS-232-C switched service connection procedure; all RS-232-C signals and procedures are covered in the section entitled Using the Interface, under the heading RS-232-C Interface. In multipoint systems without modems (RS-422 and 20-milliampere current loop), addresses are set on the ADDRESS switch (S5) on the Serial Interface assembly. Switch settings and circuit connections are covered under Interface Configuration and Installation.

ESTABLISHMENT

Introduction

Once the circuit between the 2400B and the host has been physically connected, the host must then select the 2400B it wishes to communicate with. This is called the establishment procedure. In a two-point network, there is no establishment procedure, since there is only one 2400B. In a multipoint network, however, a logical connection must be established between the host and only one 2400B.

Multipoint Addressing

In a multipoint-direct-connect system (RS-422 or current loop interface), each 2400B in the system has a unique address. Up to ten 2400B's may be connected in such a system. Each 2400B in the system is assigned an address from zero to nine, as set on the ADDRESS switch (S5) on the Serial Interface. After one 2400B is addressed, the other 2400B's remain idle until there is another address sequence.

Establishment

The host establishes an RS-422 or current loop communication link between itself and a particular 2400B computer front end in a multipoint network as follows:

1. The host sends an address character followed by the Enquiry character, ENQ. The address character is the mathematical sum of the address (0 - 9) and ASCII-coded character "0" (ASCII decimal 48).

2. When a 2400B detects its address sequence, it responds by echoing its address character followed by the Acknowledge character, ACK, causing establishment to occur.

Note

When using a multipoint system, make sure that only one 2400B is addressed at a time. The recommended way of doing this is to perform the termination sequence prior to addressing any 2400B.

MESSAGE TRANSFER

Introduction

Once a connection has been established, messages can be exchanged between the Serial Interface and the host, using various data channel protocols and message transfer protocols. This discussion is an overview; instructions regarding the use of signals and protocols are included in the section, Using the Interface.

Data Channel Protocols

The RS-422 and 20-milliampere current loop interfaces have dedicated lines for transmitting and receiving messages. The data transfer lines for the RS-232-C interface, however, can be configured in different ways: direct-connect or with modems, and full duplex or half duplex. Half-duplex communication is only useful when using modems, and can use Main Channel Protocol or Reverse Channel Protocol.

In full-duplex mode, each modem transmits data on a carrier wave of a different frequency, allowing two data channels to exist on the same line. Figure 5-3 shows how the available bandwidth of a voice-grade

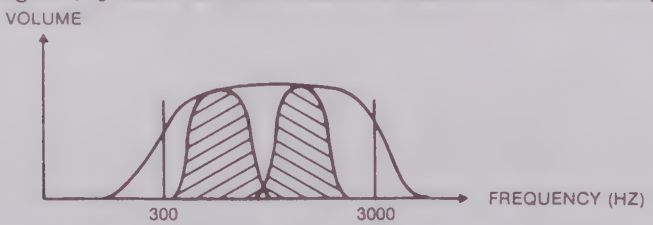

Figure 5-3. Full-Duplex Data Channels

telephone line is occupied by the two data channels in full duplex. Because the bandwidth of a digital signal gets larger with higher speed, the highest speeds are not practical in full duplex.

Higher speeds can be used in half-duplex communication, where the stations take turns sending data to the other. In Main Channel Protocol, the sending station has control of communications until it turns control over to the receiving station. This signaling happens on the same channel that carries data, so it is called Main Channel Protocol.

In applications where the receiving station must have the ability to "turn the line around," or gain control of the data line, Reverse Channel Protocol can be used. In Reverse Channel Protocol, a narrow, secondary channel is established beside the main channel, on which the receiver can signal the transmitter that it wants to become the transmitter. The transmitter always monitors the secondary channel to check to see if the receiver is acknowledging a contact. When the carrier drops out due to line disconnection, the transmitter detects the break and stops transmitting characters. Figure 5-4 gives a graphical representation of how the data channels occupy the available bandwidth of the telephone line in half duplex with reverse channel.

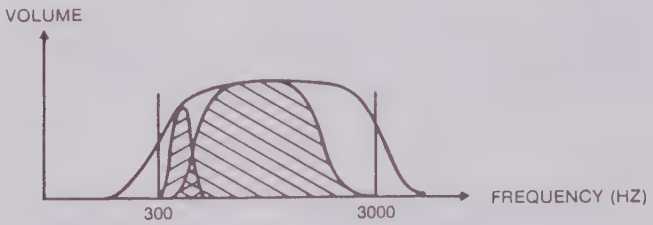

Figure 5-4. Half-Duplex Data Channel With Secondary Reverse Channel

The above paragraphs have been an introduction to the data transfer protocols used by the 2400B-001 Serial Interface, and more details of the communication signals can be found in the RS-232-C part of the Using the Interface section.

Message Transfer Protocols

This describes, starting with the simplest communication method, each message transfer protocol used by the Serial Interface. This information is included to introduce the user who is new to serial communication to the available alternatives in message transfer protocols. MESSAGE TRANSFER switch (S2) settings are given here, as well as later in this section under the heading, Interface Configuration and Installation.

Various ASCII control characters are mentioned in the following paragraphs. Table 5-3 contains the characters mentioned, with their corresponding decimal values. This is for your reference if for any reason you need to know the decimal equivalent of any of the characters. For a complete table of ASCII characters, see Appendix D.

Table 5-3. Some ASCII Mnemonics and Their Decimal Equivalents

ASCII Mnemonic	Decimal Value
ACK	6
DLE	16
ENQ	5
EOT	4
ETX	3
NAK	21
STX	6
XOFF	17
XON	19

- Simple Terminal 1

  Consider communication between two devices, A and B. In the simplest case, device A transmits characters to device B, and device B transmits characters to device A. This is called simple terminal protocol. With simple terminal protocol there is no data flow control mechanism and no mechanism for the recovery of character errors detected by the parity bit. This communication method is selected when the MESSAGE TRANSFER switch (S2) on the Serial Interface is set to position 0, labeled ST1, for Simple Terminal 1.

- Simple Terminal 2

  At low transmission speeds, Simple Terminal 1 is adequate. However, if device B is unable to receive and process characters as fast as A can send them, information is lost. Device B avoids this problem if it sends a flow control character to tell device A to stop transmitting characters until it catches up.

  In Simple Terminal 2 message transfer protocol, special characters are transmitted by the receiver to control the flow of data. When the 2400B is receiving data using Simple Terminal 2 protocol, and its buffer becomes almost full, it sends the XOFF (transmit off) character to the transmitter. The reception of XOFF causes the transmitter to halt. This is done to avoid overwriting characters, thereby losing them. When the 2400B has processed incoming characters until its buffer is nearly empty, it tells the transmitter to resume the flow of data by sending the XON (transmit on) character. This protocol is selected when S2 on the Serial Interface is set to position 1, marked ST2, for Simple Terminal 2.

- Simple Terminal 3

  If the next position of S2, position 2 (labeled ST3, for Simple Terminal 3), is selected, the same XON/XOFF protocol is used, but with a 30-second delayed XON repeat feature.

When the Serial Interface is the receiver, and halts the flow of characters from the transmitter with XOFF, the transmitter halts until it receives XON. If somehow the transmitter fails to receive an XON character sent by the Serial Interface configured for Simple Terminal 2, it will remain halted indefinitely. If Simple Terminal 3 is selected on the Serial Interface, the interface sends XON after receiving no characters from the transmitter for 30 seconds.

- Blocked 1

Although XON/XOFF protocols are very effective at getting messages transferred, they have no provision for error recovery. Blocked format protocols, however, contain error detection and recovery, as well as data flow control mechanisms. Blocked format protocols should be used whenever transmission errors are critical to the application. The Serial Interface includes two blocked format protocols, called Blocked 1 and Blocked 2.

When using a blocked format protocol, one device, called the master, is in control of the communication process at a given time. The receiving device is called the slave. Only the master can transmit messages.

A blocked format message begins when the master sends the Start of Text character, STX. This tells the slave that what follows is the text of the message. After sending the body of the message, the master sends the End of Text character, ETX, to define the end of the message block. The master then waits for a verification character from the slave before sending another message block.

Following the reception of ETX, if the slave received the message with no parity errors, it sends the Acknowledge character, ACK, to the master, telling the master it is free to send a new message block. If, however, the slave detected a parity error in any character in the message block, it sends the Negative Acknowledge character, NAK, to the master. When this happens, the master must repeat the previous message block and wait for verification again.

If, after sending a complete message block the master receives a character other than ACK or NAK, or receives no response for 30 seconds from the slave, the master then sends the Enquiry character, ENQ, to the slave. The slave then repeats its last character transmitted. This is to prevent the master from becoming stalled indefinitely if there is an error in transmitting or receiving ACK or NAK. The 2400B re-transmits a message block up to five times before giving up and going on.

This protocol is called Blocked 1 Message Transfer Protocol, and is selected by setting S2 on the Serial Interface to position 3, labeled BLOCK1.

- Blocked 2

  Blocked 2 Message Transfer Protocol is identical to Blocked 1, but with an added error detection device. Using Blocked 1 protocol, most transmission errors will be detected. However, if an even number of bits in a character get inverted by a noisy transmission line, an odd or even parity bit will not detect the error. There is a more effective error checking method that is available for use in error-sensitive applications.

  When in Blocked 2 protocol, the master calculates a longitudinal parity Block Check Character, called BCC, for the entire message. This character is calculated by a "bitwise exclusive or" of all the characters in a block, from the first character after the STX character through the ETX character. The BCC character is transmitted as part of the message block, just after ETX. At the same time, the slave generates its own BCC from the message it receives, and compares it to the BCC sent from the master. If the two match, and no other errors are detected, the slave acknowledges receipt with ACK. If they do not match, then NAK is sent to the master, causing the master to repeat the message until it is received without error, or until transmission of the block fails five times.

  Blocked 2 message transfer protocol is selected by setting S2 on the Serial Interface to position 4, labeled BLOCK2.

TERMINATION

When communicating using the RS-422 or current loop interface in a multipoint network, eventually you will need to "unaddress" the 2400B. When the communication session is complete, the host sends the mandatory disconnect character sequence, composed of the Data Link Escape character, DLE, and the End Of Transmission character, EOT. The reception of DLE EOT tells the 2400B to stop paying attention to incoming characters (until it is addressed again).

DISCONNECTION

When using the RS-232-C interface in switched service, a communication session also ends with the DLE EOT character sequence. When the 2400B receives DLE EOT, it causes its modem to hang up the telephone connection. Refer to the RS-232-C part of the Using the Interface section for more information.

CONFIGURATION AND INSTALLATION

Configuring the Interface

The Serial Interface must be configured for each of the following: interface type, bit rate, message transfer protocol, character format, modem control, and address (in a multipoint system only). This section contains instructions for setting the interface configuration switches and jumper to the settings you have chosen. This must be done before the Serial Interface can be used to communicate with a host computer.

INTERFACE TYPE (RS-232-C, RS-422, OR 20-MILLIAMPERE CURRENT LOOP)

The 2400B-001 Serial Interface must be configured to communicate using one of three electrical interfaces: RS-232-C, RS-422, or 20-milliampere current loop. Select the desired interface type as follows:

1. Hold the Serial Interface pcb assembly with the component side up and the rear panel strip to the right.

2. Referring to Figure 5-5, locate the three position jumper (W4), in the upper right quadrant of the pcb. A jumper block is plugged onto two pins on the six-contact connector designated W4, to select the desired mode.

3. Install the jumper block on the top two pins to select RS-232-C communication, the third and fourth pins to select RS-422 communication, or the fifth and sixth pins to select 20 milliampere current loop communication mode. The correct positions are printed on the component side of the pcb.

BAUD RATE

Select the desired communication baud rate as follows:

1. Hold the Serial Interface pcb assembly with the component side up and the rear panel strip to the right.

2. Referring to Figure 5-5, locate the pcb-mounted rotary switch, S1, labeled BAUD RATE.

3. Using a small screwdriver or the end of a small paper clip, rotate the center of the switch so that the arrow on the center shaft points to the desired setting printed on the pcb. Any setting listed in Table 5-4 with a "yes" is acceptable.

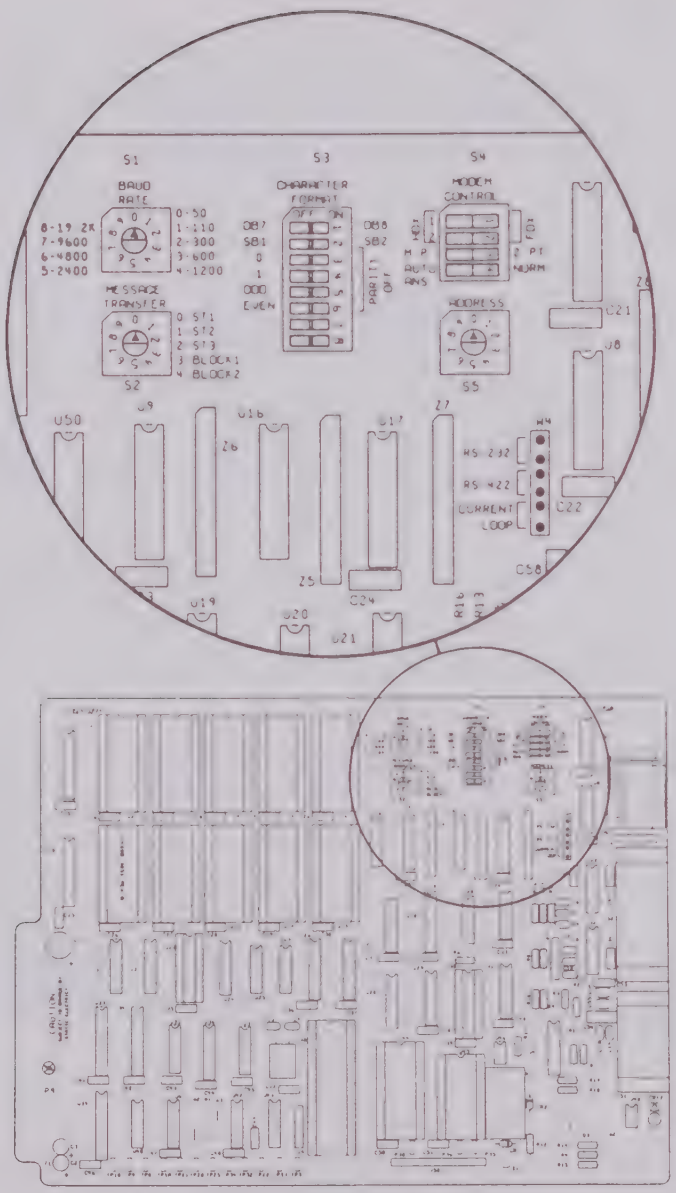

Figure 5-5. Switch and Jumper Locations

Table 5-4. Acceptable Bit Rates

S1 Setting	Baud	RS-232	RS-422	Current Loop
0	50	Yes	Yes	Yes
1	110	Yes	Yes	Yes
2	300	Yes	Yes	Yes
3	600	Yes	Yes	Yes
4	1200	Yes	Yes	Yes
5	2400	Yes	Yes	Yes
6	4800	Yes	Yes	Yes
7	9600	Yes	Yes	No
8	19200	Yes	Yes	No

MESSAGE TRANSFER

Choose a message transfer protocol, referring to the Message Transfer Procedure section of the Introduction for an explanation of each of the protocols. Paramount in choosing a message transfer protocol are the requirements of the host device interface. Other factors are transmission medium, bit rate, system configuration (two-point or multipoint),and mode (half duplex or full duplex). Before configuring the interface for a particular message transfer protocol, check in Table 5-5 to see that setting is allowed in your system. Table 5-6 shows the switch settings and pcb labels that correspond to each message transfer protocol. Select the desired message transfer protocol as follows:

1. Hold the Serial Interface assembly with the component side of the board up and the rear panel strip to the right.

2. Referring to Figure 5-5, locate S2, a rotary pcb-mounted switch labeled MESSAGE TRANSFER.

3. Turn the center of the switch with a small screwdriver or the end of a small paper clip so that the arrow on the switch points to the setting corresponding to the desired message transfer protocol. MESSAGE TRANSFER switch settings correspond to the protocols as Table 5-6 shows.

Table 5-5. Acceptable Hardware Configurations

		Direct-Connect		Auto-Answer	
		Two-Point	Multipoint	Two-Point	Multipoint
Full Duplex	ST1	Yes	Yes	Yes	Yes
	ST2	Yes	Yes	Yes	Yes
	ST3	Yes	Yes	No	No
	BLK1	Yes	Yes	Yes	Yes
	BLK2	Yes	Yes	Yes	Yes
Half Duplex	ST1	Yes	Yes	Yes	Yes
	ST2	No	No	No	No
	ST3	No	No	No	No
	BLK1	Yes	Yes	Yes	Yes
	BLK2	Yes	Yes	Yes	Yes

Table 5-6. MESSAGE TRANSFER Switch Settings

S2 Setting	Label on pcb	Message Transfer Protocol
0	ST1	Simple Terminal 1
1	ST2	Simple Terminal 2
2	ST3	Simple Terminal 3
3	BLOCK1	Blocked 1
4	BLOCK2	Blocked 2

CHARACTER FORMAT

To select seven or eight data bits, one or two stop bits, and any of five uses of parity, follow the procedure below. Refer also to Table 5-7 and the labels on the pcb. Note that only the top six positions of S3 (S3-1 to S3-6) are used. The settings of the last two segments (S3-7, S3-8) are ignored. Set the CHARACTER FORMAT segments as follows:

1. Hold the Serial Interface pcb assembly with the component side up and the rear panel strip to the right.

2. Referring to Figure 5-5, locate S3, an eight-segment DIP (Dual In-line Package) rocker switch, labeled CHARACTER FORMAT.

3. Data Bits: Rock switch segment S3-1 to the right to select eight data bits, or to the left for seven data bits.

4. Stop Bit: Rock switch segment S3-2 to the right to select two stop bits, or to the left for one stop bit.

5. Parity: First rock all four switch segments (S3-3, S3-4, S3-5, and S3-6) to the right. For no parity, leave all four segments in this position. For a "zero" parity bit, rock segment S3-3 to the left. For a "one" parity bit, rock segment S3-4 to the left. For odd parity, rock segment S3-5 to the left. For even parity, rock segment S3-6 to the left.

Only one (or none) of the four parity switch segments can be in the left position. Any other configuration is illegal, and will result in a configuration error shown on the CONF indicator on the rear panel strip.

Table 5-7 shows acceptable setting combinations of segments S3-1, S3-3, S3-4, S3-5, and S3-6 for seven or eight of data bits and various states of parity. Switch segment positions are referred to as LEFT or RIGHT, where the direction specified is the side of the switch segment depressed.

MODEM CONTROL

The MODEM CONTROL switch, S4, configures the Serial Interface for use with regular or auto-answer modems (in switched service), and two-point or multipoint operation (in a dedicated, direct-connect network). It also configures the interface for the data channel protocol to be used. Review Table 5-5, Acceptable Hardware Configurations, for a summary of allowed configurations. Discussions of the modes of operation referred to below can be found in the corresponding part of the Using the Interface section.

Referring to Figure 5-5, locate S4, the four-segment DIP rocker switch labeled MODEM CONTROL. The function of the positions of each segment are printed on the pcb, but it is recommended that you use the following systematic procedure for setting the MODEM CONTROL switch. To set the switch, go directly to the heading below for the interface type you are using. Follow the steps under the appropriate heading.

Table 5-7. Acceptable CHARACTER FORMAT Switch Settings

Selection	S3-1	S3-3	S3-4	S3-5	S3-6	Comments
7 Data Bits Parity OFF	Left	Right	Right	Right	Right	No parity bit.
7 Data Bits Parity "0"	Left	Left	Right	Right	Right	Really 8 data bits w/ msb == 0
7 Data Bits Parity "1"	Left	Right	Left	Right	Right	Really 8 data bits w/ msb == 1
7 Data Bits Parity ODD	Left	Right	Right	Left	Right	
7 Data Bits Parity EVEN	Left	Right	Right	Right	Left	
8 Data Bits Parity OFF	Right	Right	Right	Right	Right	No parity bit.
8 Data Bits Parity "0"	Right	Left	Right	Right	Right	Invalid setting (See Note)
8 Data Bits Parity "1"	Right	Right	Left	Right	Right	Invalid setting (See Note)
8 Data Bits Parity ODD	Right	Right	Right	Left	Right	
8 Data Bits Parity EVEN	Right	Right	Right	Right	Left	

Note

The settings described as invalid in the chart, and other possible settings of these five switch segments cause a configuration error to be shown on the CONF indicator on the rear panel strip of the 2400B-001 Serial Interface at power-up.

If Using RS-232-C:

1. Rock all segments S4-1, S4-2, S4-3, and S4-4 to the right.

2. For full duplex, leave S4-1 and S4-2 in the right position. For half duplex, rock either S4-1 to the left for HDX1 (main channel protocol), or S4-2 to the left for HDX2 (reverse channel protocol).

3. Leave S4-3 to the right.

4. If the Serial Interface will be used with an auto-answer modem, rock the last segment, S4-4, to the left. If any other modem besides an auto-answer modem will be used, leave S4-4 to the right.

If Using RS-422 or Current Loop:

1. Rock all segments, S4-1, S4-2, S4-3, and S4-4 to the right.

2. Leave the first two segments, S4-1 and S4-2, to the right.

3. For a two-point network, leave segment S4-3 to the right. For a multipoint network, rock S4-3 to the left.

4. The last segment, S4-4 must remain to the right for RS-422 and current loop operation.

MULTIPOINT ADDRESS

When using the RS-422 or current loop interface in a multipoint network, the ADDRESS switch must be set. There may be up to ten 2400B's in a multipoint system, with corresponding addresses of zero through nine. The setting of S5 is ignored for RS-232-C operation, and for two-point RS-422 and current loop operation.

Select the desired address as follows:

1. Hold the Serial Interface pcb assembly so that the component side is up and the rear panel strip is to the right.

2. Referring to Figure 5-5, locate S5, a pcb-mounted rotary switch labeled ADDRESS.

3. Rotate S5 with a small screwdriver or the end of a small paper clip so that the arrow on the center shaft of the switch points to the desired address.

Installing the Interface

The 2400B-001 Serial Interface assembly mounts in the pcb slot on the extreme left (looking at the rear panel) of the 2400B. This is the Communications Option Slot and is reserved for the IEEE-488 or Serial Interface Options. Install the Serial Interface assembly in the 2400B chassis as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Facing the back of the chassis, locate the left-most slot.

Caution

Handle the interface assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. Insert the pcb assembly, connector end first, into the slot.

5. To secure the interface option in place, turn the thumbscrews until they are finger-tight.

CONNECTING AND USING THE INTERFACE

Introduction

This section describes how each of the interfaces works, and how to connect all cables necessary to put the interface into operation. Each interface is discussed in its own subsection. Much of the information here is technical and theoretical; often operation of the interface is possible without knowing what the signal lines are doing. However, it is helpful to know how signals are used in a serial interface, to help solve problems that might arise when interfacing equipment made by different manufacturers.

The RS-232-C Interface

INTRODUCTION

First established in 1969 and later revised, Electronic Industries Association (EIA) standard RS-232-C defines the electrical and mechanical characteristics of an "interface between data terminal equipment and data communication equipment employing serial binary data interchange." It is the most widely accepted standard for digital data communication; few pieces of computer related equipment are supplied without an RS-232 port.

The standard assigns functions to the circuit on each pin of a 25-pin subminiature D-type connector -- female on data communication equipment and male on data terminal equipment. Signal voltage level and timing requirements are prescribed by the standard, but character format, bit rate (baud), and the use of parity bits in RS-232 compatible devices can vary. It is assumed that these parameters have been selected and configured on the interface at this point.

This section describes RS-232-C signals and communication channel protocols used by the Serial Interface. Some of this information is highly technical, but has been included here to provide you with all the signal information you might need to properly interface the 2400B-001 with different types of RS-232 interfaces.

SIGNAL DESCRIPTIONS

The Serial Interface is implemented as data terminal equipment (DTE) as described by standard RS-232-C. As a DTE unit, the interface must be connected to data communication equipment (DCE). Modems and Null-Modem Cables are examples of DCE.

The RS-232-C signals used by the Serial Interface and their functions are listed in Table 5-8 with their pin assignments. The following section gives a brief description of each circuit. The signals are also specified by Comité Consultatif International Télégraphique et Téléphonique (CCITT), and the CCITT codes are included in parenthesis.

Table 5-8. RS-232-C Circuits Supported by the Serial Interface

Pin Number	Circuit Name	Direction
1	AA Protective Ground	(Chassis Ground)
2	BA Transmitted Data	To modem
3	BB Received Data	From modem
4	CA Request to Send	To modem
5	CB Clear to Send	From modem
6	CC Data Set Ready	From modem
7	AB Signal Ground	(Reference Ground)
8	CF Received Line Signal Detect	From modem
9	(no connection)	
10	(no connection)	
11	(no connection)	
12	SCF Secondary Rec. Line Signal Detect	From modem
13	(no connection)	
14	(no connection)	
15	(no connection)	
16	(no connection)	
17	(no connection)	
18	(no connection)	
19	SCA Secondary Request to Send	To modem
20	CD Data Terminal Ready	To modem
21	(no connection)	
22	CE Ring Indicator	From modem
23	(no connection)	
24	(no connection)	
25	(no connection)	

Note

When an RS-232-C signal is high, its logic state is true, and its voltage level is more positive than plus three volts. When the signal is low, its logic state is false, and its voltage level is more negative than minus three volts.

The functions of RS-232-C signals used by the 2400B-001 Serial Interface are:

- AA (101) - Protective Ground

  Protective Ground is the common chassis ground for the Serial Interface and modem, and is connected to earth ground through the power cord.

- AB (102) - Signal Ground

  Signal Ground is the common reference for all the following interface signals.

- BA (103) - Transmitted Data

  Transmitted Data carries the stream of data bits generated by the Serial Interface to the modem.

- BB (104) - Received Data

  Received Data is the line that carries data received and demodulated by the modem to the Serial Interface.

- CA (105) - Request to Send

  Request to Send activates the modem. When this signal is high, the modem starts sending a primary carrier and the Serial Interface is in the transmit mode. In full-duplex systems, CA is always high (as long as the network is in a connected state and the equipment power is on). In half-duplex systems, CA is the signal that enables transmission at one modem and shuts off transmission at another, during line turn-around.

- CB (106) - Clear to Send

  Clear to Send is set high by the modem when CA (Request to Send) is detected to be high. CB is set high to show that the modem is sending a carrier and is ready to send data. There is often a slight response delay from the time CA is sent to the time CB goes high.

- CC (107) - Data Set Ready

  Data Set Ready is set high when the modem is powered-on and ready for operation.

- CD (108.2) - Data Terminal Ready

  Data Terminal Ready is set high when the Serial Interface is powered on and ready for operation. When an auto-answer modem is used, CD remains low until CE (Ring Indicator) is detected to be high. When CE is high, the Serial Interface responds by setting CD high. When CD is high, the modem is taken off-hook to establish a telephone line connection, and when CD is set low, the modem hangs up the line. The connection may be ended when the host sets CD low, sends the character sequence, DLE EOT, or stops sending a carrier. Also, when the Serial Interface detects CF (Received Line Signal Detect) to be low for more than 10 seconds, it sets CD low to disconnect the line.

- CE (125) - Ring Indicator

  Ring Indicator is constantly monitored by the Serial Interface when it is in the auto-answer mode. When CE is detected to be high, the Serial Interface sets CD (Data Terminal Ready) high, to instruct the modem to answer the line, establishing a communication channel with the host.

- CF (109) - Received Line Signal Detect

  Received Line Signal Detect is set high by the modem whenever it detects a suitable primary carrier in the receive state. This lets the 2400B know that the primary carrier is on.

- SCA (120) - Secondary Request to Send

  Secondary Request to Send initiates a line turn-around from receive to transmit state in half duplex, reverse channel modem networks. SCA is set low by the receiving interface when line turn-around is required. This interrupts the secondary carrier and informs the transmitting interface that the primary carrier is needed by the receiving interface.

- SCF (122) - Secondary Received Line Signal Detect

  Secondary Received Line Signal Detect is set high by the modem, in half-duplex reverse channel networks, whenever the secondary carrier is received. When the Serial Interface is in the transmit state, the secondary carrier is being received by the modem and SCF will be high.

DATA CHANNEL PROTOCOLS

When the 2400B-001 Serial Interface is installed in the 2400B, a variety of system configurations are possible in an RS-232-C system. The 2400B can be connected directly to the host computer if the units are separated by a distance of 50 feet or less. If the 2400B and the host are more than 50 feet apart, modems may be used to provide the communication medium. Communication may be established between the 2400B and the host using full-duplex or half-duplex methods.

Full Duplex

In a system employing full-duplex communication, simultaneous two-way data transfer is possible. In a full-duplex system, separate transmit and receive channels are established. These channels can be on two different carrier frequencies on the same line, or on two hard-wired direct-connect circuits. The total length of cable in a direct-connect system should be no more than 50 feet, but all bit rates are allowed. For full-duplex with modems, there is no distance limit, but the maximum bit rate practical for reliable communication is limited to 1200 baud when standard voice-grade telephone lines are used.

DIRECT CONNECTION

In a full-duplex direct-connect system the 2400B-001 and host computer are both acting as DTE. Therefore, a Null-Modem Cable must be used to simulate the presence of two modems. The Null-Modem Cable connects CA (Request to Send) to CB (Clear to Send) thus allowing the 2400B-001 to transmit at any time, and routes the transmitted data to the receive

channel at the other end. The Null-Modem Cable can be used alone or in conjunction with a standard RS-232 cable to connect the 2400B-001 to the host computer.

When the 2400B-001 is operated as part of a full-duplex direct-connect system, CA (Request to Send), SCA (Secondary Request to Send), and CD (Data Terminal Ready) are set high at power-up, to enable two-way communication.

WITH MODEMS

RS-232-C specifications allow up to 50 feet of cable in a direct connect system. For longer distances between the host and the 2400B-001, full-duplex communication can be established using modems. Two of the most commonly used modems are the Bell Standard 103, which transmits at a bit rate of 300 baud, and the Bell Standard 212A, which transmits at a bit rate of 1200 baud.

Full-duplex modems connected to the 2400B-001 and the host can be linked by a dedicated wire or a telephone line. Using full-duplex, each modem transmits data on its own channel. Each channel has its own carrier frequency, allowing two-way data transfer to take place on the same line.

In full-duplex data communication over a telephone line, there is no distance limit, but there is a limit on speed. Two communication channels must fit within the typical three kilohertz bandwidth of a telephone line. Since a signal with a higher baud has a wider bandwidth, baud is limited. When two data channels share the same line, the maximum bit rate is typically 1200 baud, depending on the type of modem (check the modem specifications).

WITH AUTO-ANSWER MODEMS

If the 2400B-001 is used with a full-duplex modem with auto-answer capability on the direct dial telephone network, the host computer can access the 2400B from a remote location. The host computer can be connected to the direct dial network with an auto-dial modem (such as the Racal-Vadic VA212PA).

At power-up the 2400B-001 interface asserts signal CD (Data Terminal Ready) low if auto-answer mode has been selected (and the line is not ringing). The host computer may dial the number for the 2400B at the remote site at any time. When it does, the 2400B-001 interface detects signal CE (Ring Indicator) high, and responds by asserting CD (Data Terminal Ready) high. This tells the auto-answer modem to answer the line and a connection is established. The modem, in turn, signals to the 2400B that the line has been answered, and communication between the host and the 2400B can begin.

When the communication session is complete, the host computer transmits the character sequence DLE EOT to the 2400B. On recognition of this character sequence, the 2400B-001 interface asserts CD (Data Terminal Ready) low, telling the modem to hang up the telephone line. CD is also set low to disconnect the line if at any time the 2400B-001 interface detects signal CF (Received Line Signal Detect) to be low for more than 10 seconds. This could be caused by line interruption, or by the host computer hanging up at its end of the line.

Half Duplex

In half-duplex mode, the data carrier occupies a greater part of the available bandwidth of the telephone line. Refer to Figures 5-3 and 5-4 for a graphical representation of full-duplex and half-duplex communication. Half-duplex (Bell 202 type) modems are available if a higher data speed is necessary when using standard telephone lines.

Half-duplex modems provide a single channel for data transmission. Data transmission can occur in only one direction and any given time. This single channel (or carrier) is used alternately by the host computer and the 2400B. Since the carrier is shared between transmitting devices, there must be an orderly method of transferring control of the carrier from one device to another. The transmitting device has control of the carrier while it is transmitting. When it is finished transmitting, control of the data channel is transferred to the receiving unit, which then has control of the carrier and can consequently transmit data. The procedure for transferring control of the carrier from one device to another is called line turn-around. The 2400B-01 supports two line turn-around procedures: Main Channel Protocol (HDX1) and Reverse Channel Protocol (HDX2).

In main channel protocol, the transmitting unit (unit A, which has control of the carrier) initiates the line turn-around procedure. Unit A turns off the carrier when it has finished transmitting. When the receiving unit (unit B) 'sees' that the carrier has been turned off, it takes control of the carrier by turning it on. Unit B now becomes the transmitting unit, and unit A is now the receiving unit. When unit B is finished transmitting, it will initiate line turn-around and the transmitting/receiving statuses of the units will again be exchanged.

In applications where the transmitting station must ensure that the receiving station is still connected to the line, and where the receiving station must have the ability to initiate line turn-around, Reverse Channel Protocol (HDX2) can be used. This protocol establishes a narrow-bandwidth secondary reverse channel for control signaling by the receiving station.

The main channel is controlled by the transmitting station and the reverse channel is controlled by the receiving station. In normal operation, the transmitter sends a modulated carrier to the receiver on the main channel, and the receiver sends a control carrier to the transmitter on the secondary reverse channel. Reverse channel protocol provides a more secure handshake between the transmitter and receiver during the line turn-around procedure.

In reverse channel protocol, the transmitting unit (unit A) has control of the main (primary) carrier and the receiving unit (unit B) has control of a secondary (or reverse) channel. The receiving unit initiates the line turn-around procedure by turning off the reverse channel carrier. When the transmitting unit 'sees' that the secondary carrier has been turned off, it turns off the primary carrier and turns on the secondary carrier. The receiver has been 'watching' the line; when it 'sees' that the secondary carrier has been turned on by the transmitting unit, it turns on the primary carrier. Unit B is now the transmitting unit, and unit A is now the receiving unit.

EXAMPLE: SIMPLE TERMINAL PROTOCOL AND MAIN CHANNEL LINE TURN-AROUND PROCEDURE

Using a simple terminal protocol with a Main Channel Protocol (HDX1), line turn-around occurs when transmitting unit transfers control of the carrier to the receiving station. The transmitter initiates line turn-around by sending the EOT character and setting CA (Request to Send) low. This causes its modem to turn off its carrier. When the receiving modem sees the carrier go off, it notifies its receiving unit that the carrier is off. The receiver then sets CA (Request to Send) high, which in turn tells its modem to turn on the carrier. The carrier is then detected by the original transmitting modem, which then sets CF (Carrier Detect) high. At this point, the transmitter and receiver have exchanged functions, completing line turn-around. Figure 5-6 graphically shows how Main Channel Protocol works.

EXAMPLE: SIMPLE TERMINAL MESSAGE TRANSFER PROTOCOL AND REVERSE CHANNEL LINE-TURN AROUND PROCEDURE.

When a simple terminal message transfer terminal protocol is used with Reverse Channel (HDX2) line turn-around procedure, line turn-around begins when the transmitter (unit A) sends the EOT character to the receiver (unit B).

When unit B receives the EOT character, it initiates the line turn-around procedure by setting SCA (Secondary Request to Send) low. This causes modem B to turn off the secondary (reverse) carrier.

When the transmitting modem (modem A) sees the secondary reverse carrier go off, it sets SCF (Secondary Received Line Signal Detect) low. The transmitter (unit A) then sets CA (Request to Send) low, and SCA (Secondary Request to Send) high. In response, modem A turns off the primary carrier and turns on the secondary carrier. When modem B sees the primary carrier go off, it sets CF (Received Line Signal Detect) low. The receiver (unit B) responds by setting CA (Request to Send) high. When CA goes high (ie. unit B is ready to transmit), and a secondary carrier is detected (ie. unit A is ready to receive), modem B turns on the primary carrier and sets CB (Clear to Send) high. When modem A detects the primary carrier, it sets CF (Received Line Signal Detect) high, which tells unit A that line turn-around is complete. When unit B sees CB (Clear to Send) go high, it can begin transmitting data. Unit B is now the transmitter and unit A is the receiver. Figure 5-7 shows a graphical representation of how Reverse Channel Protocol works.

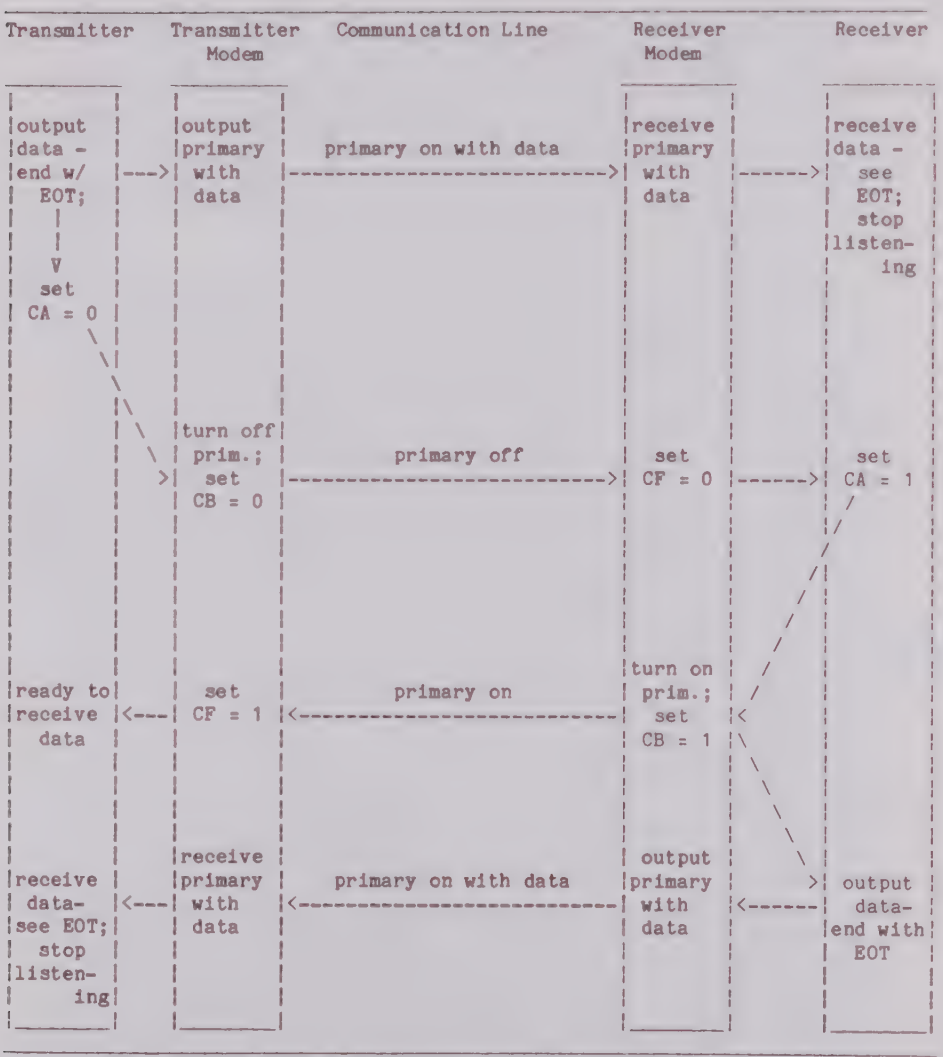

Figure 5-6. Main Channel Protocol Diagram

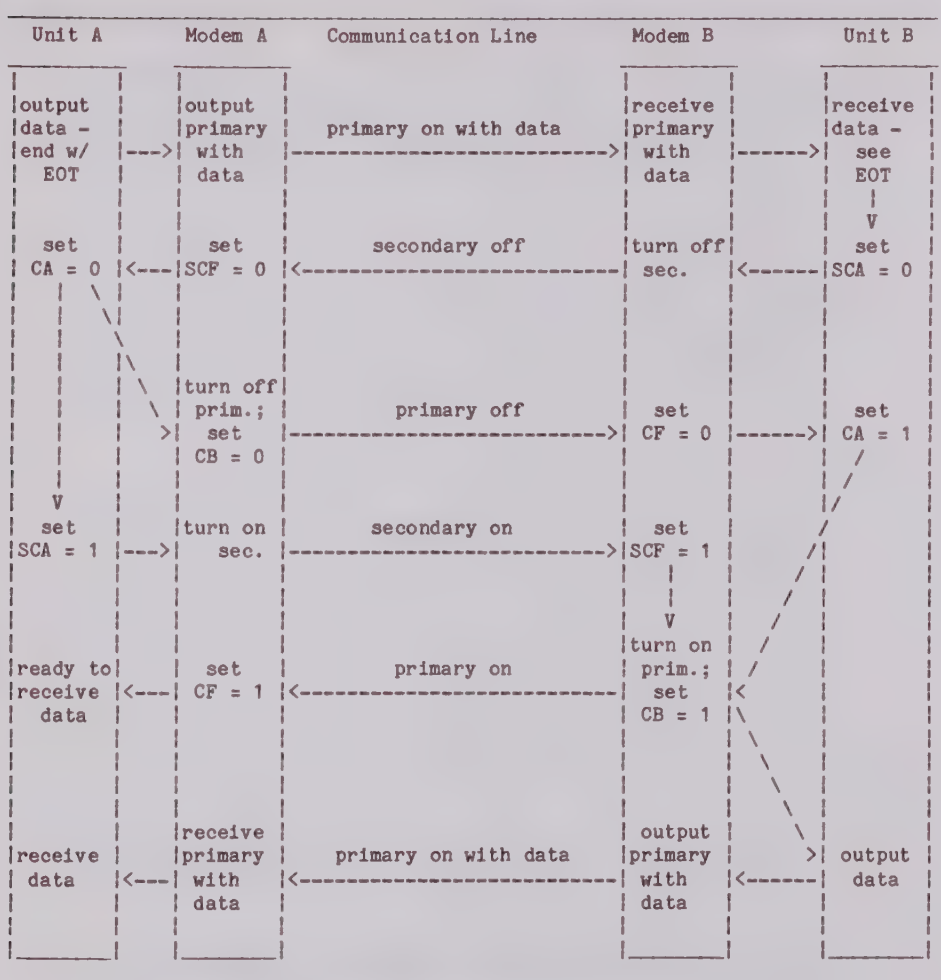

Figure 5-7. Reverse Channel Protocol Diagram

CABLE CONFIGURATIONS AND CONNECTIONS

To link the 2400B to a host computer using the RS-232-C interface, a cable must be attached between the Serial Interface and either a modem or the host itself. Use the following steps to interconnect the system you have chosen to use. Each network type has its own set of instructions.

Two-Point Direct-Connect Network

1. Connect one end of an RS-232-C Null-Modem Cable (such as the Fluke Accessory Y1702 Two-Meter Null-Modem Cable) to the male 25-pin D-type connector on the Serial Interface.

2. Connect the other end of the Null Modem Cable to the RS-232-C connector on the host computer.

3. Go to Interface Installation Verification Testing.

Two-Point With Modems Over a Dedicated Line

1. Connect one end of a standard RS-232-C cable (such as the Fluke Accessory Y1707 Two-Meter Cable) to the male 25-pin D-type connector on the Serial Interface.

2. Connect the other end of the cable to the RS-232-C connector on the modem.

3. Make similar connections between the host computer and its modem (follow the instructions supplied with the modem).

4. Go to Interface Installation Verification Testing.

Linking to the Telephone Service With an Auto-Answer Modem.

1. Connect one end of a standard RS-232-C cable (such as the Fluke Accessory Y1707 Two-Meter Cable) to the male 25-pin D-type connector on the Serial Interface.

2. Connect the other end of the cable to the auto-answer modem, following the instructions for that particular modem.

3. Go to Interface Installation Verification Testing.

The RS-422 Interface

INTRODUCTION

Electronic Industries Association (EIA) standard RS-422 gives the specifications for the "electrical characteristics of balanced voltage digital interface circuits." The RS-422 interface uses a balanced (differential) voltage signal. This allows digital communication over as much as 4,000 feet of twisted-pair 24 AWG wire at bit rates up to 19,200 baud. Two-point and multipoint configurations can be used with RS-422.

The standard does not define the mechanical interface characteristics, it is just an electrical standard. The 2400B-001 Serial Interface uses a subminiature 15-pin D-type connector (female on the interface, male on the connecting cable) to present the RS-422 signal connections. Table 5-9 lists the seven signals used by the RS-422 interface on the 2400B-001 and gives their pin assignments.

Table 5-9. RS-422 Signals and Associated Pin Assignments

Pin Number	Signal Name	Direction
1	Shield	(Chassis Ground)
2	AC Coupled Shield	AC Connection to Chassis Ground
3	R+	From Host Computer
4	R-	From Host Computer
9	T+	To Host Computer
10	T-	To Host Computer
11	Common	(Signal Common)

SIGNAL DESCRIPTIONS

To better understand how the RS-422 Interface works, a description of each of the RS-422 Interface signals follows:

- Shield

  Shield is the direct connection to chassis ground for the shield around the twisted-pair cable between the host computer and the 2400B-001. Shield is used when the devices at both end of the communication line have the same chassis potentials. This is the case when the AC power grounds at each end are the same.

  If the host and the 2400B are powered from different AC mains, there may be a difference in the chassis ground potentials at opposite ends of the RS-232 cable. This could cause undesirable current flow in the shield wire if it terminates with Shield, since Shield is a DC connection. In such situations where a voltage might exist between two chassis grounds, AC Coupled Shield should be used to terminate the shield conductor.

- AC Coupled Shield

  This is an AC coupled connection to chassis ground for the shield around the twisted-pair wire between the host and the 2400B. AC Coupled Shield provides a high frequency path to ground, while blocking DC. This prevents DC current from flowing in systems where there is a difference in chassis ground potentials at opposite ends of the RS-422 cable.

- R+

  R+ is one of two differential received data signals from the host computer. R+ is the logical inverse of R-. When R+ is more than 0.2 volts more positive than R-, the received data signal is considered to be a logic 1 (or mark) state. This is the normal state of the interface and corresponds to a stop bit. When R+ is more than 0.2 volts more negative than R-, the data signal is considered to be a logic 0 (or space) state. The space state represents a start bit at the beginning of character transmission.

- R-

  R- is the other of the two differential data signals received from the host computer. R- is the logical inverse of R+.

- T+

  T+ is one of two differential data signals transmitted to the host computer. T+ is the logical inverse of T-. When T+ is more than 0.2 volts more positive than T-, the transmitted data signal is considered to be in a logic 1 (or mark) state. This is the normal state of the interface and corresponds to a stop bit. When T+ is more than 0.2 volts more negative than T-, the data signal is considered to be in a logic 0 (or space) state. This is the state in which the interface generates a start bit at the beginning of character transmission.

- T-

  T- is the other of the two differential data signals transmitted to the host computer. T- is the logical inverse of T+.

- Common

  Common is the common reference signal for R+, R-, T+, and T-.

CABLE CONNECTIONS

Introduction

The 2400B-001 can be used as an RS-422 interface in two different system configurations. The simplest configuration is two-point, where a host computer is connected to a single 2400B. The other possible configuration is multipoint, where several 2400B's are addressable separately by a host computer.

Two-Point Configuration

After configuring and installing the Serial Interface, it can be connected for two-point RS-422 operation. Connect the network together as follows:

1. Obtain the desired length of shielded cable containing at least three twisted-pairs of conductors (minimum size 24 AWG).

2. Referring to Table 5-9 for pin assignments, install the 15-pin, subminiature D-type connector supplied with the Serial Interface (or Fluke Accessory or equivalent) on the 2400B end of the cable, making the following pin connections:

3. Connect the conductors of one twisted pair to pins 3 and 4.

4. Connect the conductors of another twisted pair to pins 9 and 10.

5. Connect one conductor of third twisted pair to pin 11.

6. Connect the cable shield(s) to pin 1.

7. Install an appropriate connector for the host computer end of the cable, making sure to attach the correct signal lines to each pin, matching the requirements of the host computer.

8. Connect each end of the cable, and proceed to Interface Installation Verification.

Multipoint Configuration

After configuring (including multipoint address) and installing the Serial Interface in each 2400B, they can be connected for multipoint RS-422 operation. Set up the network as follows:

1. Obtain enough shielded twisted-pair cable containing at least three twisted pairs (minimum size 24 AWG) to connect each link in the network, referring to Figure 5-8, Multipoint Cabling Configuration.

2. Referring to Table 5-9 for pin assignments, install the 15-pin, subminiature D-type connector supplied with the Serial Interface (or Fluke Option 2400B-604 or equivalent) on each cable end that terminates with a 2400B, making the pin connections in the next three steps:

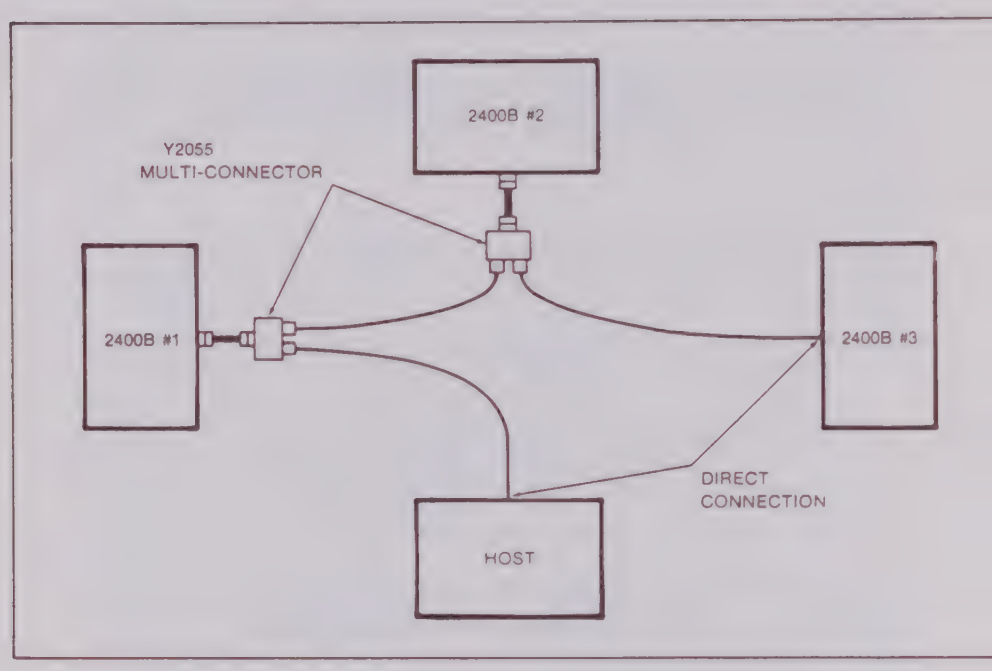

Figure 5-8. RS-422 Multipoint Cabling Configuration

3. Connect the conductors of one twisted pair to pins 3 and 4.

4. Connect the conductors of another twisted pair to pins 9 and 10.

5. Connect one conductor of a third twisted pair to pin 11.

6. Connect the cable shield(s) to pin 1.

7. Install an appropriate connector on the end of the cable that terminates with the host computer, making sure to attach the correct signal lines to each pin to match the requirements of the host computer. Attach the connector to the host computer.

8. Attach the center lead connector of an Accessory Y2055 15-Conductor Multi-Connector to all except the last 2400B in the network as shown in Figure 5-8. The other two connectors on the multi-connector are internally wired so that corresponding pins are connected in parallel.

9. Attach each of the remaining cable ends to the mating connectors on the Accessory Y2055 15-Conductor Multi-Connectors as shown in Figure 5-10.

10. Proceed to Interface Installation Verification Testing.

The 20-Milliampere Current Loop Interface

INTRODUCTION

The current loop interface has been around for many years, but is still widely used because it provides an effective communication medium in electrically noisy environments. There are two main current loop interface standards: 60-milliampere and 20-milliampere, with 20-milliampere the most common. Current loop interfaces provide simultaneous bidirectional communication, in two-point or multipoint networks, over a maximum of 5000 feet of hard-wired interface cables (see Table 5-2 for maximum allowable cable runs).

In a current loop network, one of the devices must provide the current source and sink for all devices incorporated in the loop. The 20-milliampere current loop interface on the 2400B-001 Serial Interface can be set up to be active or passive. When used as an active interface, a current generator on the assembly provides the 20-milliampere loop current. In most cases, however, the host device is the active interface, and all 2400B-001 interfaces must be wired as a passive interface.

SIGNAL DESCRIPTIONS

Passive Interface

The passive current loop interface consists of a current detector and a current transmitter (which works like a switch, turning the loop current off and on). There are four lines on the 2400B-001 current loop interface providing all necessary passive interface functions. They are as follows:

- IR+, the receive current input
- IR-, the receive current output
- IT+, the transmit current input
- IT-, the transmit current output

Note

Current enters a terminal designated with a plus sign, and leaves a terminal designated with a minus sign.

For an equivalent circuit diagram of the current loop transmitters and receivers, see Figure 5-9.

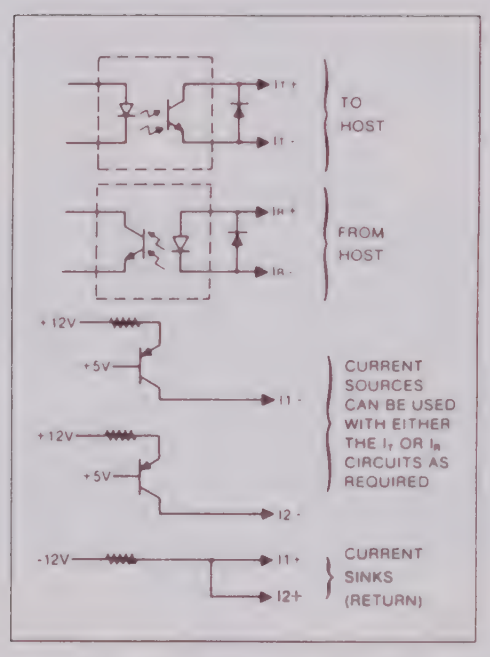

Figure 5-9. Current Loop Interface Equivalent Circuit

Active Interface

The active current loop interface has the same lines with the same functions as the passive interface, except that it also provides a current source and sink for the transmit loop and the receive loop. These additional functions are provided by the following lines on the Serial Interface:

- I1+, the transmit loop current sink
- I1-, the transmit loop current source
- I2+, the receive loop current sink
- I2-, the receive loop current source

These four lines remain unconnected when the interface is used as passive, but must be used in the interface cable circuit when the interface is used as active. Table 5-10 gives the pin assignments on the 15-pin D-connector that correspond to each line. Figure 5-10 shows how a multipoint system is connected. A two-point system works similarly, with one of the devices active and the other passive.

Table 5-10. Current Loop Interface Connector Pin Assignments

Signal	Pin Number
IR+	6
IR-	7
IT+	13
IT-	14
I1+	8
I1-	5
I2+	15
I2-	12

CABLE CONNECTIONS

Circuit connection procedures for two-point and multipoint current loop networks follow. For both systems, however, the first step is to determine whether the host interface is active or passive, and to wire the connector on the host end of the interface cable accordingly. Make the wire connections using the following procedure:

Connections at the Host

Since signal names will be different with host devices of different types and made by different manufacturers, refer to the host device's documentation (and the circuit connection information below) to wire the connector at the host end of the cable.

Connections at the 2400B

Now the connection to one or more 2400B-001 Serial Interfaces must be made. There is a separate discussion for interface connections for two-point and multipoint networks. Follow the instructions under the appropriate heading.

TWO-POINT

1. Obtain a 15-pin D-type connector (Fluke Option 2400B-604 or equivalent, one is supplied with the Serial Interface), and enough four-conductor wire (minimum size 24 AWG) to link the 2400B and host.

2. If host is the active interface, skip steps 3 through 5 and go on to step 6. If the host is a passive interface, do steps 3 through 5 to configure the 2400B as the active interface. There must be only one active interface in the loop.

3. Two pairs of signal lines must be connected together with jumpers across the corresponding pin connections in the connector at the 2400B, as follows: Connect pin 6 (IR+) to pin 5 (I1-). Connect pin 13 (IT+) to pin 12 (I2-). These jumpers tie the two current generators into the receive and transmit loops, respectively.

4. Connect the conductor from the receive loop output from the host to pin 15 (I2+) of the connector at the 2400B.

5. Connect the conductor from the transmit loop output from the host to pin 8 (I1+) of the connector at the 2400B. Now go on to step 8.

6. Connect the conductor from the receive loop output from the host to pin 13 (IT+) of the connector at the 2400B.

7. Connect the conductor from the transmit loop output from the host to pin 6 (IR+) of the connector at the 2400B.

8. Connect the conductor from the receive loop input to the host to pin 14 (IT-) at the 2400B.

9. Connect the conductor from the transmit loop input to the host to pin 7 (IR-) at the 2400B.

10. After attaching the connector to the 2400B-001 Serial Interface 15-pin connector, go to Interface Installation Verification Testing.

MULTIPOINT

1. Obtain a 15-pin D-type connector (Fluke Option 2400B-604 or equivalent) for each 2400B in the network (up to ten). Cut lengths of two-conductor wire (minimum size 24 AWG) to link each 2400B and the host in a loop as shown in Figure 5-10.

2. If host is the active interface, skip steps 3 through 5 and go on to step 6. If the host is a passive interface, do steps 3 through 6 to configure the first 2400B in the loop as the active interface. There must be only one active interface in the loop.

3. Two pairs of signal lines must be connected together with jumpers across the corresponding pin connections in the connector at the 2400B, as follows: Connect pin 6 (IR+) to pin 5 (I1-). Connect pin 13 (IT+) to pin 12 (I2-). These jumpers tie the two current generators into the receive and transmit loops, respectively.

4. Connect the conductor from the receive loop current output from the host to pin 15 (I2+) of the connector at the 2400B.

5. Connect the conductor from the transmit loop current output from the host to pin 8 (I1+) of the connector at the 2400B.

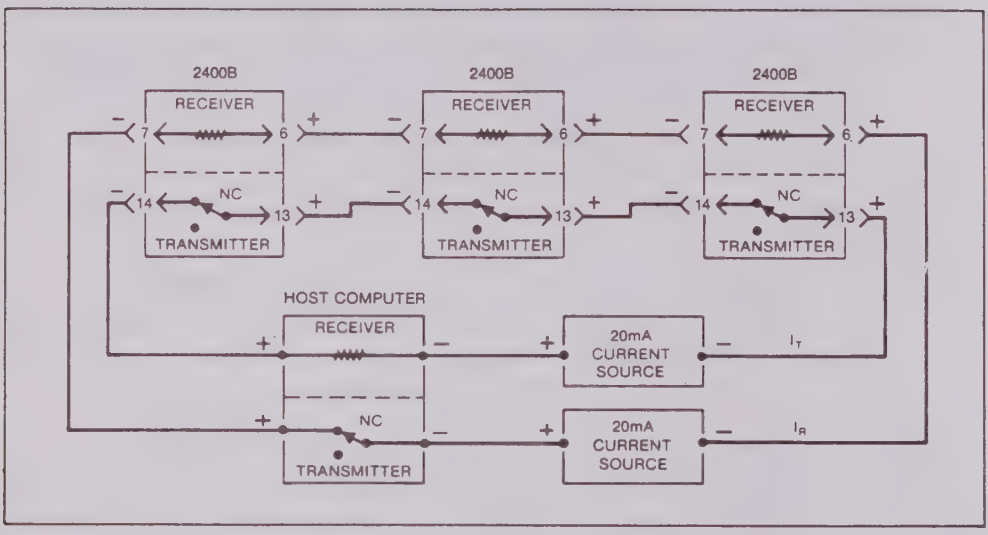

Figure 5-10. Multipoint Current Loop Network

6. Cut a length of two-conductor wire (at least 24 AWG) that is long enough to reach the next 2400B in the loop, and connect the conductors of one end to pins 7 (IR-) and 14 (IT-).

7. At the next 2400B in the loop, connect the conductor from pin 7 (IR-) on the previous connector to pin 6 (IR+) on the new connector. Connect the conductor from 14 (IT-) on the previous connector to pin 13 (IT+) on the new connector.

8. Repeat steps 6 and 7 until the connector for the last 2400B in the loop has been partly wired.

9. Cut a length of two-conductor wire that is long enough to reach the host computer, and connect the conductors of one end to pins 7 (IR-) and 14 (IT-) on the new connector.

10. The other ends of this last wire connect to the host computer so that the conductor from the receive loop input to the host connects to pin 14 (IT-) at the last 2400B in the loop.

11. The conductor from the transmit loop input to the host connects to pin 7 (IR-) at the last 2400B in the loop.

12. Go to Interface Installation Verification Testing.

INTERFACE INSTALLATION VERIFICATION TESTING

When interface configuration and installation is complete, the 2400B should be tested to verify correct operation. The following installation verification test should be performed regardless of the type of host computer you are using.

The following test steps refer to LED (light-emitting diode) indicators on the 2400B front and rear panels. The indicators reflect the operating status of the 2400B and the 2400B-001 Serial Interface. The front-panel indicators and their functions are described in Section 3, Installation. The indicators on the 2400B-001 Serial Interface rear panel strip are described at the beginning of this section.

Follow these steps to verify correct installation and operation of the interface:

1. Connect the host computer to the 2400B using the appropriate equipment and cables for the type of electrical interface (RS-232-C, RS-422, or 20-milliampere current loop) and check to make sure each connection is tight.

2. Connect the host computer and the 2400B to line power.

3. Set the 2400B POWER switch to ON and watch the front panel indicators. The WAITING indicator should be lit for three seconds, then go off immediately after the POWER indicator lights.

4. Turn the 2400B POWER switch OFF and then ON again and watch the indicators on the Serial Interface rear panel. The TEST and CONF indicators should turn off within a second, and the SYS indicator should go off about two seconds later.

5. Switch the host computer on and perform the appropriate line establishment procedure as discussed previously in this section (i.e. address a multipoint 2400B, auto-dial a 2400B on the direct-dial telephone system, etc.). Remember, a two-point direct-connect system does not require an establishment procedure.

6. Send the following command to the 2400B from the host computer and observe the front panel indicators:

   ```
   LIGHT = 1 !
   ```

7. The TRANSMIT/RECEIVE indicator should blink and the USER DEFINED indicator should light if the 2400B is operational.

8. Send the following command to the 2400B from the host computer:

   ```
   SEND 2+2 !
   ```

9. Verify that the response from the 2400B to the host computer indicates a result of 4.

If the Test Fails

If the 2400B System does not function properly, check all connections, then try the installation verification test again. If the system fails to function properly again, verify the interface of the host computer with another interface to eliminate it as the source of the problem. If the host computer functions properly, and the proper line establishment procedure was followed, contact your nearest John Fluke Sales Representative.

SECTION 6

IEEE-488 INTERFACE OPTION

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INTRODUCTION

Option 2400B-002 IEEE-488 Interface is one of two interface options available to connect the host computer (controller) to the 2400B. Either the IEEE-488 Interface or the Serial Interface (Option 2400B-001) is required in a 2400B System. The IEEE-488 Interface allows an IEEE-488-1978 compatible host to control and program the 2400B. This option is recommended when:

- Your host computer or controller has an IEEE-488 communications port.
- The 2400B will be less than 20 meters (66 feet) from the host.
- You are constructing a system in which the other instruments will communicate to the host through the IEEE-488 Bus.

If all three of these conditions are not true, the Serial Interface should be used instead. For a description of the Serial Interface, and information about its applications, see Section 5, Serial Interface Option.

DESCRIPTION

The IEEE-488 Bus

The Institute of Electrical and Electronic Engineers (IEEE) published a "Standard Digital Interface for Programmable Instrumentation Systems" in 1975. This standard was revised in 1978, and a supplement was published in 1980. The Standard IEEE-488-1978 is accepted throughout the instrument industry. It permits a wide variety of measurement equipment to be connected easily, forming a programmable instrumentation system. Electronic instruments may communicate with each other through the IEEE-488 Bus if they all conform to the IEEE-488 interface standard.

A brief description of bus operation is presented here. Much of this discussion is technical and has been included to help first time users visualize how a measurement and control system can be run on the IEEE-488 Bus. Although perhaps complicated in appearance, an IEEE-488 system is easy to use.

BUS ARCHITECTURE

The IEEE-488 standard describes a bus architecture and defines the timing and handshaking (signals that control data transfer) that occur on the bus. The bus, as defined by the standard, consists of sixteen lines: three dedicated handshake lines, five bus management lines, and eight data lines. The handshake lines direct the flow of data between all devices on the bus. The bus management lines establish various conditions necessary in the different units for data transfer to take place. The data lines transfer data to and from units throughout the system.

THREE-WIRE HANDSHAKE

All IEEE-488 bus devices use a three-wire handshake to coordinate the exchange of information on the data lines. The handshake signals are:

- DAV -- Data Valid
- NRFD -- Not Ready For Data
- NDAC -- Not Data Accepted

COMMANDS

A bus controller may send universal commands or commands that address an individual instrument on the bus. Universal commands may be placed on the bus over the dedicated bus management lines or the data lines. The three-wire handshake sequence must be followed when commands are sent on the data lines. Commands issued on bus management lines do not require handshaking sequences.

TYPES OF DEVICES ON THE BUS

Four types of devices may exist on the IEEE-488 Bus:

- Controllers -- Host devices that direct the transfer of data.
- Listeners -- Devices capable of accepting data.
- Talkers -- Devices that place data on the bus.
- Listener and Talkers -- Devices capable of accepting and sending data (but only one device may be a talker on the bus at one time).

IEEE-488 listeners and talkers are activated when directed by commands. An IEEE-488 listener is a device capable of accepting commands and data placed on the bus by a controller or talker device. A device listens when it is addressed as a listener. Once addressed as a listener, the device will remain a listener until it receives the unlisten (UNL) command from the controller (host computer). Likewise, an IEEE-488 talker must be addressed as a talker and remain a talker until it receives the untalk (UNT) command.

ADDRESSES

In IEEE-488 Bus operations, all devices on the bus remain passive until addressed as either a listener or talker. An address is a data byte transferred using a handshake sequence. The first five bits are the individual instrument address, and bit six and seven determine whether the instrument is to be a listener or talker. The eighth bit is not used in addressing.

The host establishes the role of all instruments connected on the bus by sending them commands and setting up the correct communications channels. Each piece of equipment recognizes its own address, which is determined by the setting of its configuration switches.

FURTHER REFERENCE

A complete list of IEEE-488 and ASCII codes is in Appendix D, Section 11. Pin assignments for the IEEE-488 connector are given in the Installation Quick Reference, Section 10. Theory of operation and troubleshooting information can be found in the IEEE-488 Interface Option Section of the 2400B Service Manual. Answers to specific questions about the IEEE-488 Bus can often be found by checking in the Appendices, Section 11.

THE IEEE-488 INTERFACE

The IEEE-488 Interface is a plug-in printed circuit board (pcb) assembly that contains all the hardware and software necessary to link the 2400B to a host computer on the IEEE-488 Bus. An IEEE-488 24-pin port in the middle of the rear panel strip (the back edge of the pcb) provides the connection point to the bus. The IEEE-488 bus address of the 2400B is determined by the setting of the five-segment IEEE-488 address switch located just above the IEEE-488 port (see Figure 6-1).

The pcb assembly is shipped mounted in the Communication Option slot (left-most slot) in the back of the 2400B. Thumbscrews at the top and bottom of the rear panel of the interface secure the pcb assembly in place. Figure 6-1 shows where the IEEE-488 Interface is mounted in the 2400B chassis.

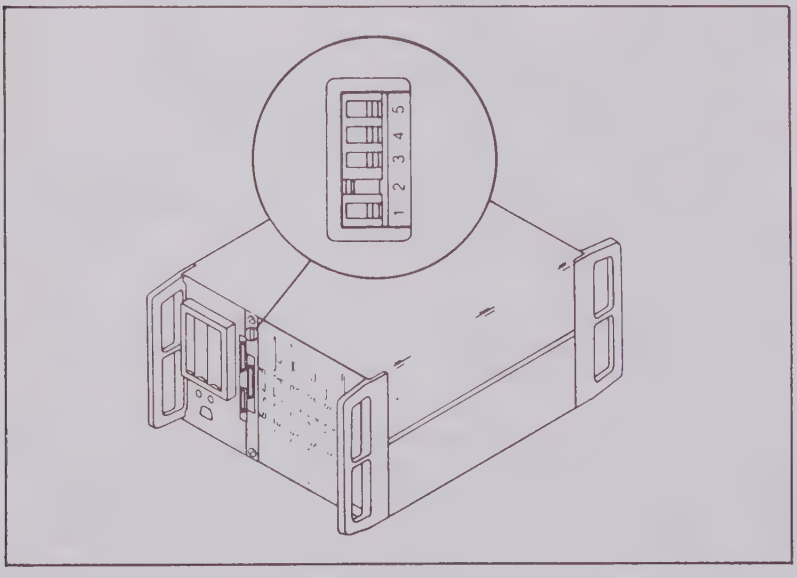

Figure 6-1. IEEE Interface and Address Switch Location

INSTALLATION

The IEEE-488 Interface assembly mounts in the pcb slot on the extreme left (looking at the rear panel) of the 2400B. This is the Communications Option Slot and is reserved for the IEEE-488 or Serial Interface Options. Install the IEEE-488 Interface Option as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Facing the back of the chassis, locate the left-most slot.

Caution

Handle the interface assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. Insert the pcb assembly, connector end first, into the slot.

5. To secure the interface option in place, turn the thumbscrews until they are finger-tight.

IEEE-488 Address Selection

The 2400B and the host device communicate through the IEEE-488 Bus. Since several devices may be using the bus, each device must have a unique address. The five-segment switch on the interface selects an IEEE-488 address.

Figure 6-1 shows the five-segment switch, with its segments designated 1 (A1) through 5 (A5), starting at the bottom with A1. Switch segment A1 is the least significant bit (LSB), and switch segment A5 is the most significant bit (MSB) of the address. A switch segment is set to a binary 1 by moving the switch arm to the left, and to a binary 0 by moving the switch arm to the right.

Set the desired IEEE-488 address from Table 6-1 by positioning the switch segments to the left for 1 and to the right for 0 to select the proper binary address number.

Table 6-1. IEEE-488 Address Switch Settings

LISTEN ADDRESS (MLA) AND TALK ADDRESS NO. 1 (MTA1)	TALK ADDRESS NO. 2 (MTA2)	SWITCH SETTINGS A5	A4	A3	A2	A1
0	1	0	0	0	0	X
2	3	0	0	0	1	X
4	5	0	0	1	0	X
6	7	0	0	1	1	X
8	9	0	1	0	0	X
10	11	0	1	0	1	X
12	13	0	1	1	0	X
14	15	0	1	1	1	X
16	17	1	0	0	0	X
18	19	1	0	0	1	X
20	21	1	0	1	0	X
22	23	1	0	1	1	X
24	25	1	1	0	0	X
26	27	1	1	0	1	X
28	29	1	1	1	0	X
(Switch settings 11110 and 11111 are not valid)						

NOTE:

Switch Setting 1=Left (open)
Switch Setting 0=Right (closed)
Switch Setting X=1 or 0

INSTALLATION VERIFICATION TESTS

When installation is complete and the IEEE-488 address switch is set, the 2400B should be tested to verify correct operation. The following general installation verification test should be performed regardless of which controller you are using. After completing the general test, do the appropriate controller-dependent installation test.

The following tests refer to LED (light-emitting diode) indicators on the 2400B front panel. The indicators reflect the operating status of the 2400B. The indicators and their functions are described in Section 3, Installation.

General Installation Verification Test

Follow these steps to verify correct installation and operation of the interface:

1. Connect the host device to the 2400B using an IEEE-488 cable (such as Fluke Accessory Y8001, Y8002, or Y8003) and check to see that each connection is tight.

2. Connect the host device and the 2400B to line power.

3. Set the 2400B POWER switch to ON. The WAITING indicator should be lit for three seconds, then go off immediately after the POWER indicator lights.

5. Switch the host device on and continue with the controller-dependent installation verification tests.

Controller-Dependent Installation Verification Tests

Specific tests for four common controllers are given in the following paragraphs. If your controller is not a Fluke 1722A, Hewlett Packard 9825A or 9835A, or Tektronix 4051, then devise a test patterned after the one given.

FLUKE 1722A

When using the Fluke 1722A Instrument Controller as the host device, use the following test to verify correct installation and operation of the 2400B-002 IEEE-488 Interface:

1. The address set on the IEEE-488 address switch during interface installation must be entered on program line 10. This example assumes that an IEEE-488 address of 2 was set on the switch. Verify this setting.

2. Enter the following program through the Fluke 1722A Controller keyboard:

```
10 A%=2%
20 PRINT @A%, 'LIGHT = 1!'
```

3. Enter RUN and press the RETURN key. The USER DEFINED indicator will light if the 2400B is operational.

4. Enter and run the following program through the 1722A keyboard:

```
10 A%=2%
20 PRINT @A%, 'SEND 2+2 !'
30 INPUT @A%, R$
40 PRINT R$
```

5. If the interface is operational, a 4 will be written on the 1722A display.

TEKTRONIX 4051

When using the Tektronix 4051 as the host device, use the following test to verify correct installation and operation of the 2400B-002 IEEE-488 Interface:

1. The address set on the interface IEEE-488 address switch must be entered on program line 10. The following example assumes that an IEEE-488 address of 2 has been selected. Verify this setting.

2. Enter the following program through the Tektronix 4051 keyboard:

```
10 A=2
20 PRINT A: 'LIGHT = 1 !'
```

3. Enter RUN on the keyboard, then press the RETURN key. The USER DEFINED indicator will light if the interface is operational.

4. Enter and run the following program:

```
10 A=2
20 PRINT A: 'SEND 2+2 !'
30 INPUT A: R
40 PRINT R
```

5. If the interface is operational, a 4 will be written on the Tektronix 4051 display.

HEWLETT PACKARD 9825A

When using the Hewlett Packard 9825A as the host device, use the following test to verify correct installation and operation of the 2400B-002 IEEE-488 Interface.

1. The address set on the 2400B IEEE-488 address switch during interface installation, along with the select code for the Hewlett Packard 9825 IEEE-488 interface, must be entered on program line 0. The following example assumes the 2400B IEEE-488 address to be 2, and the Hewlett Packard 9825 IEEE-488 select code to be 7. Verify these settings.

2. Enter the following program through the Hewlett Packard 9825A keyboard:

```
0: wrt 702, 'light = 1 !'
```

3. Press the RUN key. The USER DEFINED light on the 2400B will light if the interface is operational.

4. Enter and run the following program:

```
0: wrt 702, 'send 2+2 !'
1: red 702, R
2: dsp R
```

5. The result, 4.00, will be written on the Hewlett Packard 9825A display if the 2400B IEEE-488 Interface is operational.

HEWLETT PACKARD 9835A

When using a Hewlett Packard 9835A as the host device, use the following test to verify correct installation and operation of the 2400B-001 IEEE-488 Interface:

1. The address set on the 2400B IEEE-488 address switch during installation of the interface, along with the Hewlett Packard 9835A IEEE-488 interface select code, must be entered on program line 10. The following example assumes the 2400B IEEE-488 address to be 2, and the Hewlett Packard 9835A IEEE-488 select code to be 7. Verify these settings.

2. Enter the following program through the Hewlett Packard 9835A keyboard:

```
10 Fluke = 702
20 OUTPUT Fluke; 'LIGHT = 1 !'
30 END
```

3. Press the RUN key on the keyboard. The 2400B USER DEFINED indicator will light if the interface is operational.

4. Enter and run the following program:

```
10 Fluke = 702
20 OUTPUT Fluke; 'SEND 2+2 !'
30 ENTER Fluke; R$
40 DSP R$
50 END
```

5. The result, 4, will be written on the Hewlett Packard 9835A display if the 2400B IEEE-488 Interface is operational.

If The Test Fails

If the 2400B system does not function properly, check all connections, then try the installation verification test again. If the system fails to function properly again, test the controller on another instrument to eliminate it as the source of the problem. If the controller works, reseat the IEEE-488 Interface pcb assembly in the 2400B and try the test again. In the event of further difficulty, refer to the IEEE-488 Interface Option section of the 2400B Service Manual for troubleshooting procedures.

SECTION 7

ANALOG INPUT OPTIONS

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Option 2400A-106 Current Input Connector 106-1
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OPTION 2400A-101 HIGH PERFORMANCE SCANNER

Description

The High Performance Scanner (Option 2400A-101) is a plug-in, 10-channel, 3-wire, dry-reed relay scanner. It operates as a low-level analog data multiplexer, linking the A/D Converter to external measurement points. The scanner accepts a variety of analog inputs, depending on the type of connector used (see OPERATION). All channels are provided with shield lead inputs.

The High Performance Scanner is a printed circuit board assembly that mounts in any of the I/O option slots in the 2400B Intelligent Computer Front End or 2401A Scanner Extender Chassis. A maximum of 100 High Performance Scanner assemblies may be installed per system, providing up to 1000 channels.

Input voltages are applied through a 44-pin, card-edge connector that mates with Thermocouple Input, Voltage Input, Current Input, and AC Volts option connectors. Channel addresses are determined by the I/O option slot occupied by the scanner. Figure 101-1 shows the analog input channel blocks assigned to the I/O option slots. Specifications for the High Performance Scanner are given in Table 101-1.

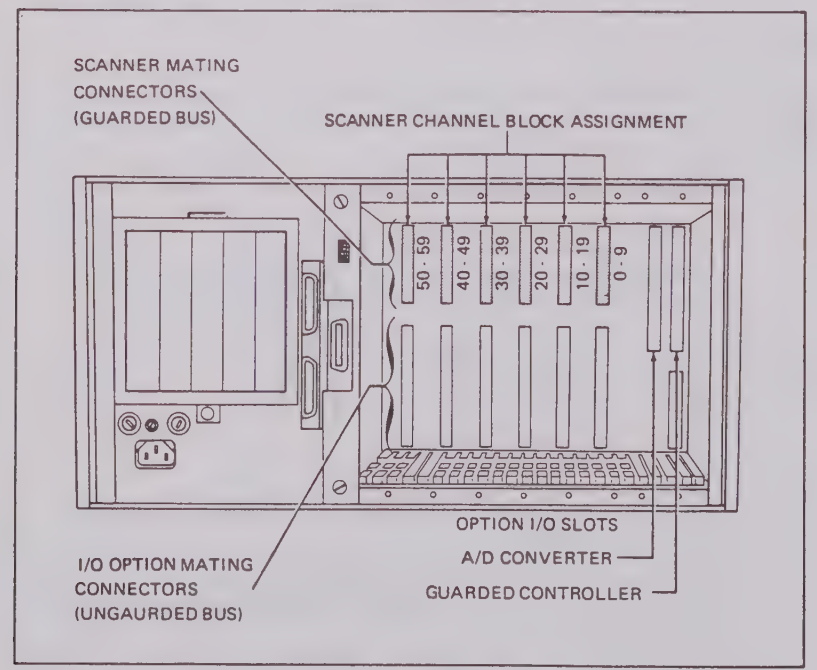


Figure 101-1. Scanner Channel Locations

Table 101-1. High Performance Scanner Specifications

Number of Channels	10 per assembly.
Maximum Number of Channels	1000 (a maximum of 100 assemblies in an extended system).
Channel Relays	30 reed relays.
Poles Per Channel	3 (High, Low, Shield).
Shield Switching	1 switch per channel
Voltage Offset (Thermal Uncertainty)	Less than or equal to 1 μV.
Max. Input Voltage Limit (Common Mode and/or Normal Mode)	Up to 350V dc and/or peak ac between any input terminal and any other terminal and/or ground.
Weight	0.9 kg. (2 lb.)
Environmental	Meets all the environmental specifications of the 2400

Installation

The High Performance Scanner mounts in any of the available I/O Option slots in the 2400B or 2401A, as Figure 101-2 shows. Install the scanner as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connector cables from the chassis.

3. Remove the rear panel from the chassis.

Caution

Handle the scanner assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. To select the best I/O option slot for mounting the scanner, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the scanner in the slot selected, so that its offset card-edge connector is toward the front of the unit and the large card-edge connector is toward the rear of the unit as shown in Figure 101-2. Push the scanner back into the chassis mating connector.

6. Rotate the plastic locking tabs located at the top and bottom of the pcb until they click into place.

7. Reinstall the connectors and cables removed in Step 2.

8. Reinstall the rear panel, removing the scanner-cover sections as necessary.

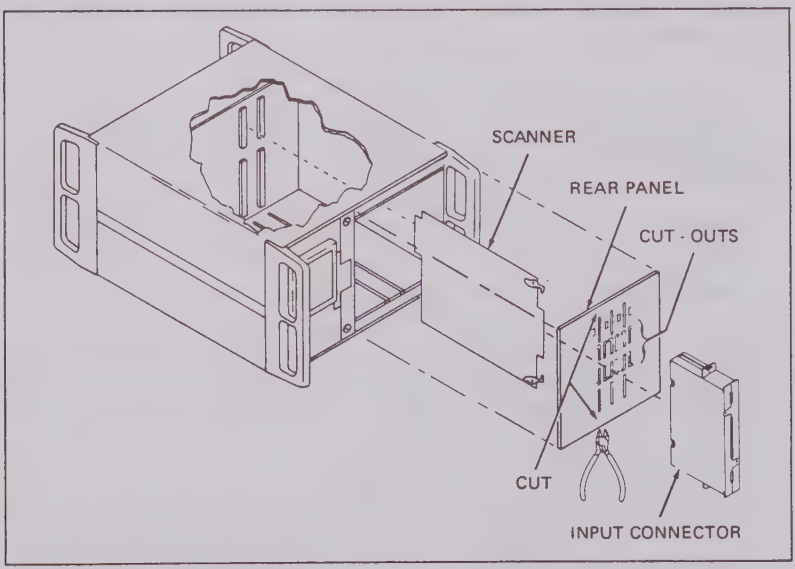


Figure 101-2. Scanner Mounting Location

Operation

After installation, the High Performance Scanner is ready for use. The user must complete wiring connections from the scanner to external measurement points, using suitable input connectors. The rear input connector on the scanner mates with various input connector assemblies.

Options that can be used with the High Performance Scanner include the following:

- o Thermocouple Input Connector (Option 2400A-102)
- o Current Input Connector (Option 2400A-106)
- o Voltage Input Connector (Option 2400A-108)
- o AC Volts Input Connector (Option 2400A-119)

Each connector is designed for a specific measurement application: Temperature, current, DC voltage, or AC voltage. Refer to the appropriate option subsection for a description of each connector option.

Installation Verification Test

To verify proper installation of the scanner, set up and sample a single scanner channel using a voltage calibrator to generate a known input to the channel. Use the following procedure to set up and sample a single scanner channel:

1. Set the calibrator output to 0 volts.

2. Connect input connector channel 0 of the to the voltage output terminals of the calibrator (HI to POSITIVE, LO and SHIELD to NEGATIVE).

3. Apply power to the 2400B by depressing the front panel POWER switch.

4. Address the 2400B through the host device, and enter the command:

   SEND AI(0) !

5. Verify that the value returned by the 2400B equals 0. (Plus or minus calibrator error).

6. Set the Calibrator output to 100 mV dc.

7. Enter the command:

   SEND AI(0) !

8. Verify that the value returned is 0.10000 volts (plus or minus calibrator error).

This completes the installation verification test. Turn off power and remove all test connections.

Service Information

Calibration procedure, troubleshooting procedure, parts list, schematics, and theory of operation are given in the 2400B Service Manual.

OPTION 2400A-102 THERMOCOUPLE INPUT CONNECTOR

Description

The Thermocouple Input Connector Assembly is a card-edge connector assembly that allows up to 10 thermocouples or voltage inputs to be connected to the High Performance Scanner (Option 2400A-101). The connector assembly mounts on the back of a scanner assembly installed in the 2400B Intelligent Computer Front End chassis or 2401A Scanner Extender chassis.

Input connections are made using three screw terminals per channel labeled HI, LO and SHIELD. The terminals can withstand a maximum of 350V dc. All terminals are surrounded by an aluminum isothermal block that remains within 0.05 degrees Celsius of the input terminal temperature. A temperature sensor on the block provides a reading used by the 2400B during thermocouple linearization; the process that converts a thermocouple voltage to a temperature value.

The connector assembly mates to the scanner with a 44-pin, card-edge connector. The entire assembly is encased in a plastic clamshell housing. The clamshell is easily separated to provide access to terminal connections. Strain relief for the external wiring is provided by the clamshell. Thermocouple Input Connector specifications are given in Table 102-1.

Table 102-1. Thermocouple Input Connector Specifications

Connector Type	Thermocouple input
Terminal Style	Screw-type
Number of Terminals	Three terminals (HI, LO, SHIELD per channel). 30 per assembly.
Compatibility	Mates with the High Performance Scanner Assembly (Option 2400A-101).
Temperature Difference Between any Two Terminals	±0.1 degree Celsius maximum.
Reference Junction Accuracy	±0.05 degrees Celsius between 18 and 28 degrees ambient temperature, increasing to ±0.15 degree Celsius at 0 and 50 degrees Celsius.
Max. Input Voltage (Common Mode or Normal Mode).	350V dc and/or peak ac between any terminal and any other terminal and/or ground.
Weight	.9 kg. (2 lb.)

Installation

The Current Input Connector mounts in any available I/O option slot containing a High Performance Scanner (see Figure 102-1). Install the connector as follows:

1. Set chassis POWER switch to OFF.

2. Locate the desired I/O option slot on the rear panel and check to ensure that a scanner pcb is installed in the slot.

3. Separate the halves of the clamshell by gently prying apart the locking tabs with your fingers.

4. Starting at channel 0, attach external wiring as necessary for your application (See following Operation paragraphs for help with wiring the connector.)

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key to the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws to secure the input connector to the chassis rear panel.

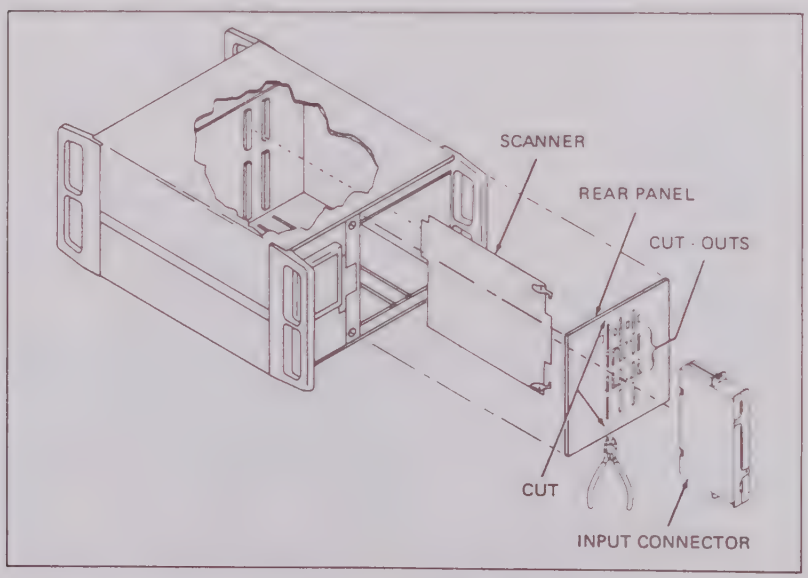


Figure 102-1. Input Connector and Scanner Mounting Location

Operation

Once installed in the chassis, the Thermocouple Input Connector is ready to receive signals from thermocouples or other DC voltage sources. The high and low leads from the thermocouple attach to the terminals indicated on the label on the clamshell and in Figure 102-2. To ensure the most accurate readings, attention must be given to the SHIELD terminal on the input connector. The SHIELD lead improves rejection of common-mode voltage noise by the 2400B.

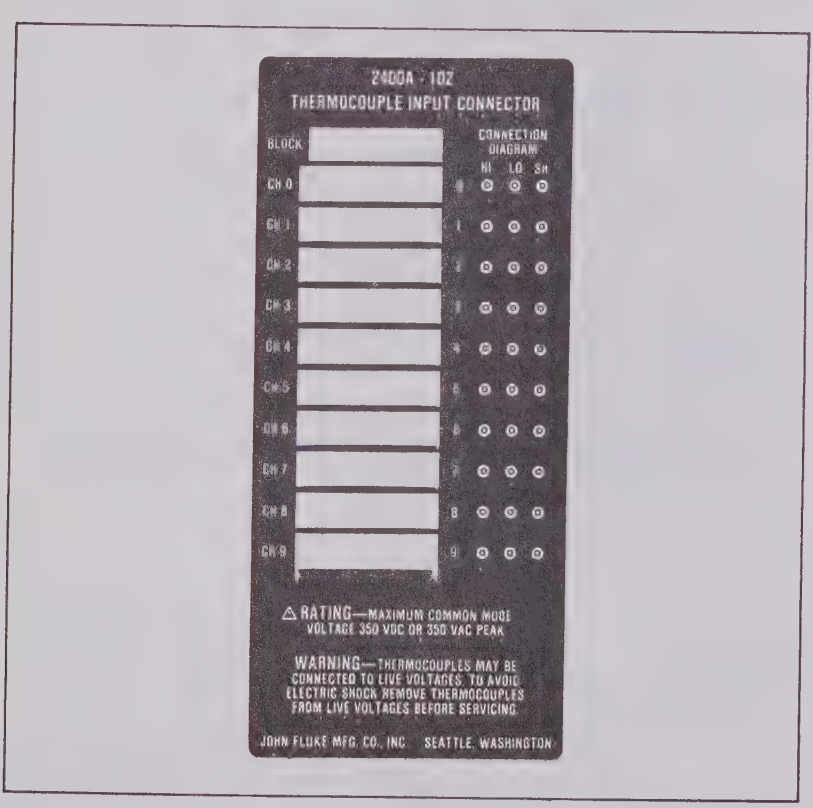


Figure 102-2. Thermocouple Input Connector Terminal Locations

When common-mode voltage is present, SHIELD should be connected to the LO lead at the measurement point. This connection provides a path for current to flow as the capacitance between the A/D Converter and the chassis charges or discharges. This current can produce unstable

readings. Since the A/D Converter and the Shield (built into the instrument) are forced to track the same voltage when SHIELD and LO are connected, the common-mode current in the HI and LO leads is minimized. The lines HI, LO, and SHIELD are fully isolated and capable of being safely floated to 350 volts above ground. Use the following guidelines when wiring the Thermocouple Input Connector:

- If significant RFI (Radio Frequency Interference) or EMI (Electro-Magnetic Interference) is present, connect SHIELD to LO on the input connector with the shortest path possible.
- If significant common mode voltage (greater than one volt) is present, connect SHIELD to LO with a third wire at the measurement point, as Figure 102-3 shows.
- For Thermocouples, connect SHIELD to the low thermocouple lead as close to the thermocouple junction as possible without affecting its temperature.
- Never tie SHIELD to HI. This could amplify the effects of noise on the signal, causing degradation in measurement accuracy.
- Never leave SHIELD unconnected. Static charge buildup may cause the maximum SHIELD to LO voltage to be exceeded, resulting in instrument damage.
- Never connect SHIELD to the 2400B chassis ground. This will result in greatly increased common mode currents because of the large value of capacitance between the shield and the A/D Converter.

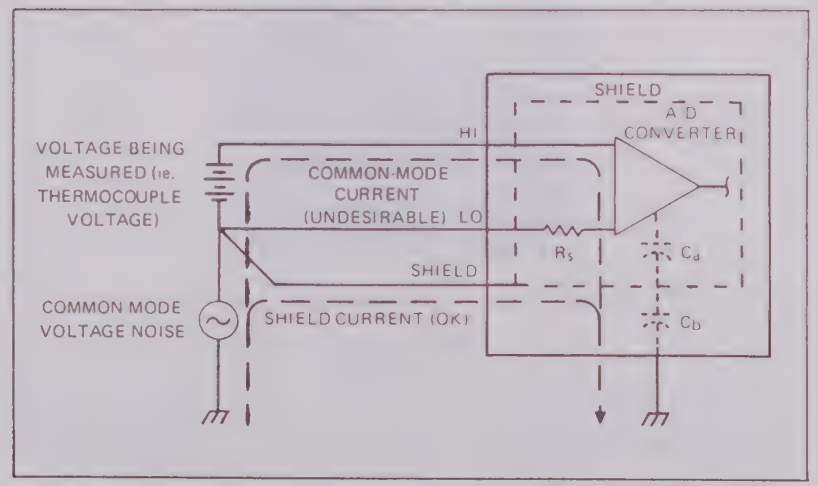


Figure 102-3. Shield Connection for Optimum Common Mode Rejection

For further information on this subject, refer to the Fluke Application Bulletin AB-20. The Application Bulletin is available from your Fluke Sales Representative.

Installation Verification Test

Verify correct Thermocouple Input Connector installation by performing the High Performance Scanner (Option 2400A-101) installation verification test after installing the input connector on the scanner.

Service Information

Theory of operation, calibration procedures, troubleshooting procedures, parts lists, and schematics are presented in the 2400B Service Manual.

OPTION 2400A-106 CURRENT INPUT CONNECTOR (4 TO 20 MILLIAMPERES)

Description

The Current Input Connector option is a card-edge connector assembly that allows the High-Performance Scanner (Option 2400A-101) to make DC current measurements in the 4 to 20 milliampere range. The connector mounts on the back of a High Performance Scanner assembly in a 2400B Intelligent Computer Front End or 2401A Scanner Extender chassis.

The Current Input Connector accepts DC current inputs from external sources and converts each current input to a proportional DC voltage using a precision shunt resistor. This voltage is then sampled by the scanner. The value returned by the 2400B will be a percentage of the input range. For example, a 4 milliampere reading will be reported as 0.0 (percent) and a 20 milliampere reading will be reported as 100.0 (percent). The full input range is determined only by the power handling ability of the shunt resistors. Inputs of 0 milliamperes (-25.0%) and 100 milliamperes (600%) are therefore possible. Up to 10 inputs can be assigned to each Current Input Connector.

Input connections are made using screw terminals, with three terminals per input (HI, LO, and SHIELD) as Figure 106-1 shows. Connection to the scanner is through a 44-pin card-edge connector. The entire Current Input Connector assembly is encased in a plastic clamshell casing. Specifications for the Current Input Connector are given in Table 106-1.

Installation

The Current Input Connector mounts in any available I/O option slot containing a High Performance Scanner (see Figure 106-2). Install the connector as follows:

1. Set chassis POWER switch to OFF.

2. Locate the desired I/O option slot on the rear panel and check to ensure that a scanner pcb is installed in the slot.

3. Separate the halves of the clamshell by gently prying apart the locking tabs with your fingers.

4. Starting at channel 0, attach external wiring as necessary for your application (See following Operation paragraphs, and refer to Figure 106-1).

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key to the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws to secure the input connector to the chassis rear panel.

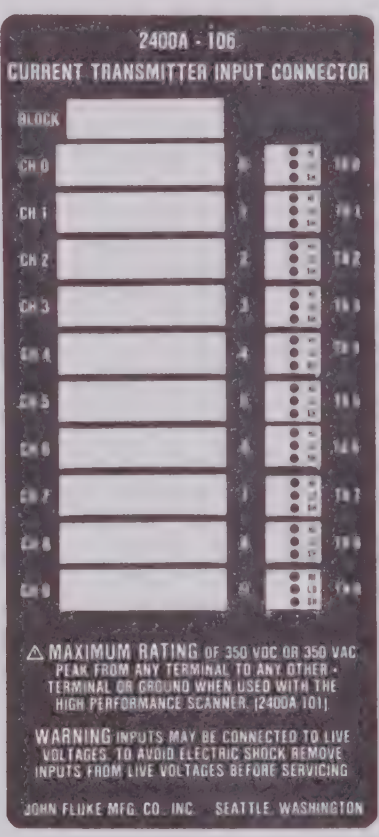

2400A - 106
CURRENT TRANSMITTER INPUT CONNECTOR
BLOCK
CH 0
CH 1
CH 2
CH 3
CH 4
CH 5
CH 6
CH 7
CH 8
CH 9
MAXIMUM RATING OF 350 VDC OR 350 VAC PEAK FROM ANY TERMINAL TO ANY OTHER TERMINAL OR GROUND WHEN USED WITH THE HIGH PERFORMANCE SCANNER (2400A 101)
WARNING INPUTS MAY BE CONNECTED TO LIVE VOLTAGES. TO AVOID ELECTRIC SHOCK REMOVE INPUTS FROM LIVE VOLTAGES BEFORE SERVICING
JOHN FLUKE MFG. CO., INC. SEATTLE, WASHINGTON

Figure 106-1. Current Input Connector Terminal Locations

Operation

Once installed in the chassis, the Current Input Connector requires no operator attention. However, to obtain the most accurate measurements, attention must be given to the connection of the SHIELD terminal on the input connector.

The purpose of the SHIELD connection is to improve the 2400B's rejection of externally generated common-mode voltage noise. This is done by connecting the SHIELD lead to the LO lead at the measurement point as shown in Figure 106-3.

Table 106-1. Current Input Connector Specifications

Connector Type	Current Input
Compatibility	Mates with a 2400A-101 High Performance Scanner Assembly.
Number of Inputs	10 per assembly.
Number of Terminals	Three per channel (HI, LO, and SHIELD) with a current shunt resistor connected between High and Low terminal. 30 terminals per assembly.
Terminal Style	Screw type
Normal Range	4 to 20 mA dc
Maximum Input Without Damage	-129 to 129 mA dc
Shunt Resistance	15 ohms
Maximum Input Power (Per Channel)	0.25 watts
Accuracy of Measurement (1 Year, 15°C to 33°C)	Add 0.1% of normal range.
Temperature Coefficient (0 to 50 Degrees Celsius)	0.0015% of reading ±0.001% of range/degrees Celsius.
Max. Common-Mode Voltage	350V dc and/or peak between any two channels.
Weight	0.4 kg. (1 lb.)

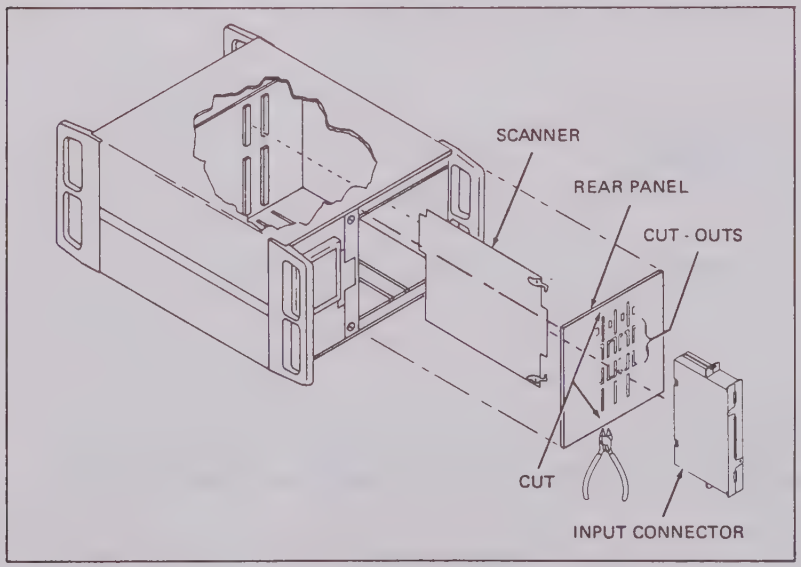


Figure 106-2. Connector and Scanner Mounting Locations

In the presence of common-mode voltage, the SHIELD to LO connection provides a path for the current to flow as the capacitance between the A/D Converter and the chassis charges or discharges. Since the A/D Converter and the Shield (built into the instrument) are forced to track the same voltage, the common-mode current in the HI and LO leads is minimized. This current produces unstable readings. Note that HI, LO and SHIELD are fully isolated and capable of being safely floated to 350 Volts above ground. The following guidelines should be followed when connecting the Current Input Connector.

- If significant RFI (Radio Frequency Interference) or EMI (Electro-Magnetic Interference) is present, the best measurement results will be obtained by connecting SHIELD to LO on the input connector with the shortest path possible.

- If significant common mode voltage (greater than one volt) is present, connect SHIELD to LO with a third wire at the measurement point as Figure 106-3 shows.

- Never tie SHIELD to HI. This could amplify the effects of noise on the signal, causing a degradation in measurement performance.

- Never leave SHIELD unconnected. Static charge build-up may cause the maximum SHIELD to LO voltage to be exceeded, resulting in instrument damage.

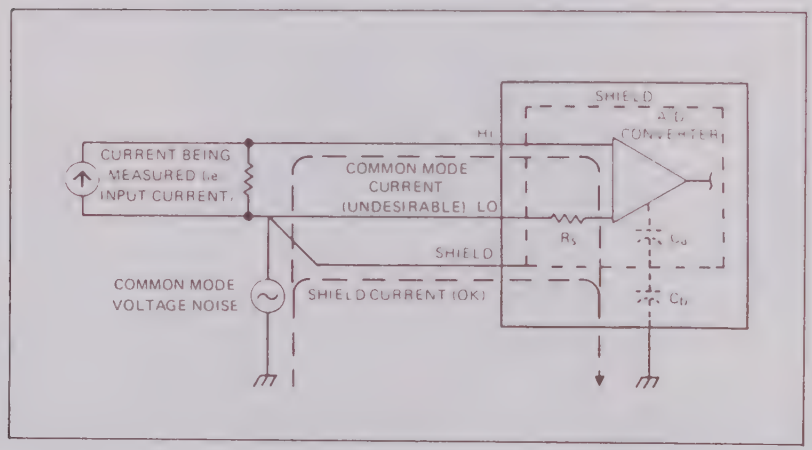


Figure 106-3. Shield Connection for Optimum Common Mode Rejection

- Never connect SHIELD to the 2400B chassis ground. This will result in greatly increased common mode currents because of the large value of capacitance between the shield and the A/D Converter.

For further information on this subject, refer to the Fluke Application Bulletin AB-20. Application Bulletin AB-20 is available from your Fluke Sales Representative.

Installation Verification Test

Correct Current Input Connector installation can be verified by installing the connector on a High Performance Scanner Assembly (2400A-101),then performing the High Performance Scanner installation verification test.

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation can be found in the 2400B Service Manual.

OPTION 2400A-108 VOLTAGE INPUT CONNECTOR

Description

The Voltage Input Connector is a card-edge connector assembly that allows up to 10 voltage inputs to be connected to the High Performance Scanner (Option 2400A-101). The connector assembly mounts at the rear of the scanner assembly in either the 2400B Intelligent Computer Front End or 2401A Scanner Extender chassis.

Input connections are made using screw terminals, with three terminals per input (HI, LO, and SHIELD) as Figure 108-1 shows. Connection to the scanner is made through a 44-pin card-edge connector. The entire Voltage Input Connector assembly is housed in a plastic clamshell housing. The clamshell is easily removed from the assembly to provide access to the screw terminals. Strain relief for the external wiring is provided by the clamshell. Voltage Input Connector specifications are given in Table 108-1.

Installation

The Voltage Input Connector can be mounted in any 2400B or 2401A I/O option slots containing a High Performance Scanner assembly. See Figure 108-2 for Voltage Input Connector mounting locations. Install the connector as follows:

1. Set chassis POWER switch to OFF.

2. Locate the desired I/O option slot. There should be a scanner assembly installed in the slot.

3. Separate the halves of the clamshell by gently prying apart the locking tabs with your fingers.

4. Starting at channel 0, attach external wiring as necessary for your application (See Figure 108-1 and the following Operation paragraphs.)

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key to the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws that hold the input connector to the chassis rear panel.

8. Repeat the procedure for additional connectors and install the rear panel enclosure.

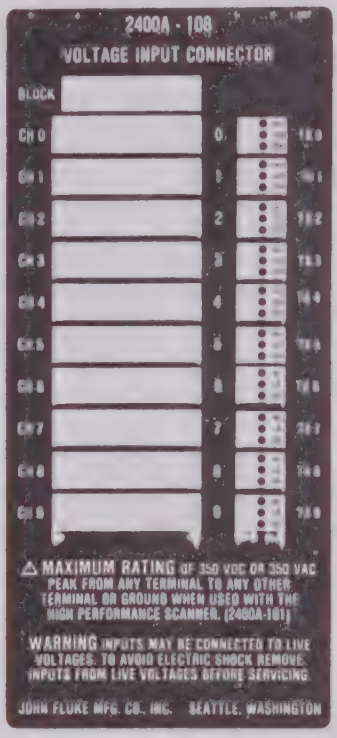

2400A - 108
VOLTAGE INPUT CONNECTOR
BLOCK
CH 0
CH 1
CH 2
CH 3
CH 4
CH 5
CH 6
CH 7
CH 8
CH 9
MAXIMUM RATING OF 350 VDC OR 350 VAC PEAK FROM ANY TERMINAL TO ANY OTHER TERMINAL OR GROUND WHEN USED WITH THE HIGH PERFORMANCE SCANNER. (2400A-101)
WARNING INPUTS MAY BE CONNECTED TO LIVE VOLTAGES. TO AVOID ELECTRIC SHOCK REMOVE INPUTS FROM LIVE VOLTAGES BEFORE SERVICING.
JOHN FLUKE MFG. CO., INC. SEATTLE, WASHINGTON

Figure 108-1. Voltage Input Connector Terminal Locations

Table 108-1. Voltage Input Connector Specifications

Connector Type	Voltage Input
Compatibility	Mates with a 2400A-101 High Performance Scanner Assembly.
Number of Inputs	10 per assembly.
Number of Terminals	3 per channel (High, Low, and Shield), a total of 30 terminals.
Terminal Style	Screw type
Maximum Input Voltage (common mode and/or normal mode)	350 Volts between any terminal and any other terminal and/or ground.

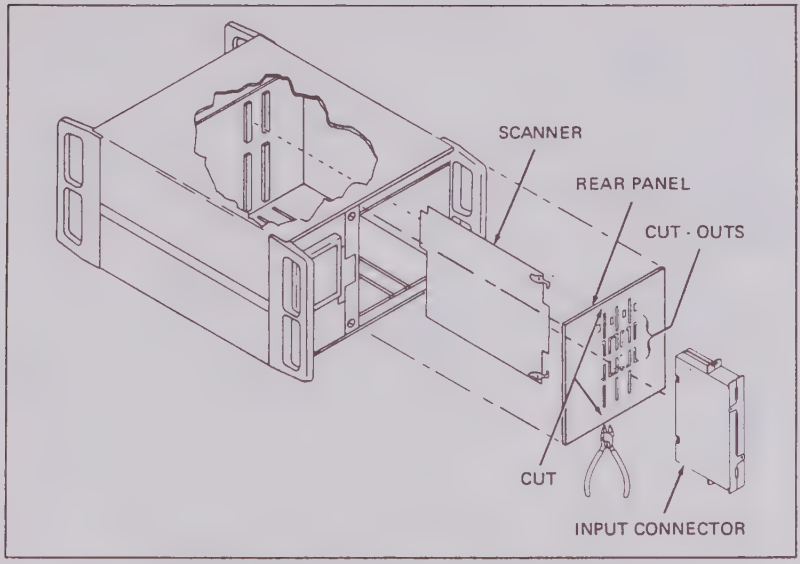


Figure 108-2. Connector and Scanner Mounting Locations

Operation

Once installed in the chassis, the Voltage Input Connector is ready for use. However, to obtain the most accurate measurements, attention must be given to the connection of the SHIELD terminal on the input connector.

The purpose of the SHIELD connection is to improve rejection of common-mode voltage noise by the 2400B. This is done by connecting the SHIELD lead to the LO lead at the measurement point as shown in Figure 108-3.

In the presence of common-mode voltage, this connection provides a path for current flowing as capacitance between the A/D Converter and the chassis charges or discharges. Since the A/D Converter and the SHIELD (built into the instrument) are forced to track the same voltage, the common-mode current in the HI and LO leads is minimized. This current can produce unstable readings. Note that HI, LO, and Shield are fully isolated and capable of being safely floated to 350 Volts above ground. Use these guidelines when connecting the Voltage Input Connector.

- If significant RFI (Radio Frequency Interference) or EMI (Electro-Magnetic Interference) is present in the measurement environment, the best measurement results will be obtained by connecting SHIELD to LO on the input connector with the shortest path possible.

- If significant common mode voltage (greater than one volt) is present, connect SHIELD to LO with a third wire at the measurement point as Figure 108-3 shows.

- Never tie SHIELD to HI. This can amplify the effects of noise on the signal, causing degradation of measurement accuracy.

- Never leave SHIELD unconnected. Static charge build-up may cause the maximum SHIELD to LO voltage to be exceeded, resulting in possible instrument damage.

- Never connect SHIELD to the 2400B chassis ground. This will result in greatly increased common mode currents because of the large value of capacitance between the shield and the A/D Converter.

For further information on the subject, refer to the Fluke Application Bulletin AB-20. It is available through your Fluke Sales Representative.

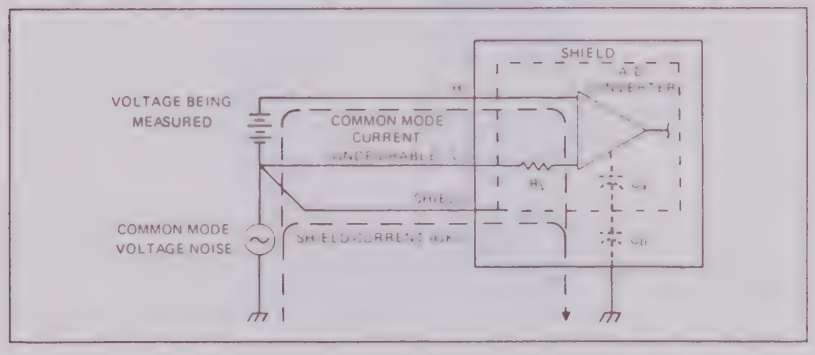


Figure 108-3. Shield Connection for Optimum Common-Mode Rejection

Installation Verification Test

Correct Voltage Input Connector installation can be verified by installing the connector on a High Performance Scanner Assembly (2400A-101), then performing the High Performance Scanner installation verification test.

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation, can be found in the 2400B Service Manual.

OPTION 2400A-109 HIGH PERFORMANCE A/D CONVERTER

Description

Option 2400A-109 is comprised of two plug-in printed circuit board (pcb) assemblies: The A/D Converter assembly and the Guarded Controller assembly. The Guarded Controller controls the operation of the A/D Converter and provides a bidirectional communication link with the 2400B Central Processor. The A/D Converter contains the buffering and sampling circuitry necessary for analog-to-digital conversion. Specifications for the High Performance A/D Converter are given in Table 109-1.

The High Performance A/D Converter provides dual slope analog-to-digital conversion of scanner input voltages. Four ranges are available to the user: 0.1V, 0.8V, 6.4V and 100V. All four ranges can be programmed through the Guarded Controller.

Table 109-1. High Performance A/D Converter Specifications

Measurement Method	Modified dual-slope a/d Conversion (refer to the Theory of Operation in the 2400 Service Manual).
Measurement Speed (60 Hz Powerline)	3 readings per second (integration over 5 line cycles. 30 readings per second (integration over 1 line cycle).
Measurement Speed (50 Hz Powerline)	2.5 readings per second (integration over 5 line cycles). 25 readings per second (integration over 1 line cycles).
Dynamic Range	±64,000 to ± 100,000 counts both speeds, depending on range.
Ranges	Range — Resolution 0.1V — 1 μV 0.8V — 10 μV 6.4V — 100 μV 100V — 1 mV
Input Impedance	>200 megohms in parallel with 0.5 μF at 3 readings/sec or 0.005 μF at 30 readings/second. 10 megohms on 100 Volt range.
Zero Stability	Automatic Zero
Overload Without Damage	350V dc or peak ac at any input range.
Overrange Indication	Error message available to the host indicated by the front panel ERROR light.
Common Mode Rejection	With the SHIELD driven from the source and 1 kilohm imbalance between HI and LO:

Table 109-1. High Performance A/D Converter Specifications (cont.)

	Speed (Readings/s)	DC Rejection	At Pwr. Line Freq.
	3	150 dB	160 dB
	30	140 dB	140 dB

Common Mode Voltage Maximum ... 350V dc or peak ac.

Normal Mode Rejection ..... 70 dB @ 50 or 60 ± 2 Hz (3 readings/sec)
55 dB @ 50 or 60 ± 2 Hz (30 readings/sec)

Accuracy (expressed as a percentage of input plus number of counts plus microvolts.)

0.1V, 0.8V, 6.4V RANGES

	ACCURACY AT 3 AND 30 READINGS/S					
	24 HRS @ 21-25°C		90 DAYS @ 18-28°C		1 YEAR @ 13-33°C	
	3	30	3	30	3	30
% OF INPUT	±0.002	±0.002	±0.005	±0.005	±0.01	±0.01
NUMBER OF COUNTS	±2	±4	±3	±5	±4	±6
MICROVOLTS	±2	±4	±2	±4	±4	±6

100V DC RANGE

	ACCURACY AT 3 AND 30 READINGS/S					
	24 HRS @ 21-25°C		90 DAYS @ 18-28°C		1 YEAR @ 13-33°C	
	3	30	3	30	3	30
% OF INPUT	±0.008	±0.008	±.01	±.01	±0.02	±0.02
NUMBER OF COUNTS	±2	±4	±3	±5	±4	±6

NOTE: A channel reading may have an additional error caused by the reading on the previous channel. This error is less than .0001% of the voltage on the previous channel and always less than 6 microvolts. Also, analog input readings do not reach rated accuracy for a period of 15 seconds after power up or reset. The system initialization takes place during this time, and analog readings should not be requested.

Table 109-1. High Performance A/D Converter Specifications (cont.)

Temperature Coefficient ..... ±0.001% of input ±0.2 counts/°C except on 100V scale +0.002% of input ±0.2 counts/°C.

Self-Test Voltages ..... 6.3V, 0.095V available under program control accurate to ±.02% for 1 year from calibration for ambient temperature between 13 and 33°C.

Thermocouple Measurement Accuracy (includes all error sources: Reference junction, conformity, A/D conversion).

THERMOCOUPLE TYPE	RANGE (°C)	[1]ACCURACY AT 3 AND 30 READINGS/S					
		AT CALIBRATION		90 DAYS 18 TO 28°C		1 YEAR 13 TO 33°C	
		3	30	3	30	3	30
JNBS	-200 to -100	.3	.4	.35	45	.4	.5
	-100 to +200	.2	.3	.25	.35	.3	.4
	+200 to +760	.2	.3	.35	.35	.4	.4
KNBS	-225 to -100	.3	.4	.35	.45	.4	.5
	-100 to +200	.2	3	.25	.35	.3	.4
	+200 to +1350	.2	.3	.4	.5	.5	.6
TNBS	-230 to -100	.3	.4	.35	.45	.4	.5
	-100 to +200	.2	.3	.25	.35	.3	.4
	+200 to +400	.2	.3	.25	.35	.3	.4
ENBS	-250 to -100	.3	.4	.35	.45	.4	.5
	-100 to +250	.2	.3	.25	.35	.3	.4
	+250 to +1000	2	.3	.35	.45	.5	.6
RNBS	0 to +200	.4	.65	.9	1.15	1.1	1.35
	+200 to +1767	.4	.65	.7	.95	.9	1.15
SNBS	0 to +200	.4	.65	.9	1.15	1.1	1.35
	+200 to +1767	.4	.65	.7	.95	.9	1.15
BNBS	+200 to +1850	.4.	.75	.7	1.05	.9	1.25
CNBS	0 to +2315	.4	.55	.7	.85	.9	1.05
NNBS	-200 to -100	.3	.4	.35	.45	.4	.5
	-100 to +200	.2	.3	.25	.35	.3	.4
	+200 to +1300	.2	.3	.4	.5	.5	.6
JDIN	-200 to -100	.3	.4	.35	.45	.4	.5
	-100 to +200	.2	.3	.25	.35	.3	.4
	+200 to +900	.2	.3	.35	.45	.4	.5

[1]All values are expressed in ±°C.
Maximum conformity error on all thermocouples = 0.05°C.

NOTE: Add an additional 0.1°C error to the above specifications for any thermocouple channel installed within two slots of an Interface or I/O card.

Table 109-1. High Performance A/D Converter Specifications (cont.)

Open Thermocouple Detector	Guarenteed to trip for source impedance >10k Ohms.
Open Thermocouple Detection Method.....	Performed by means of low level, high frequency square wave which does not upset the operation of other devices on the same thermocouple.
Open Thermocouple Indication	Host display shows 10,000 degrees regardless of units specified.
Weight	1.2 kg. (2.5 lb.) Combined weight of A/D Converter and Guarded Controller assemblies.
System Power Consumption	20 watts

Installation

The A/D Converter and Guarded Controller mount in the right-most two slots in the 2400B chassis, as Figure 109-1 shows. Install the assemblies as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove the rear panel from the chassis.

Caution

Handle the two assemblies by their edges to avoid contaminating either pcb with oil from the hands. The use of gloves is recommended.

3. Facing the back of the chassis, locate the right-most two slots. The extreme right slot is reserved for the Guarded Controller assembly. The slot beside it is reserved for the A/D Converter assembly.

4. Insert the Guarded Controller assembly, connector end first, into its chassis slot. Ensure that the pcb is right-side up. Push the pcb onto the mating connector in the chassis.

5. Repeat Step 4, placing the A/D Converter assembly in the slot next to the Guarded Controller.

6. Install the desired Option assembly or assemblies.

Note

If the High Performance Scanner option is to be installed next to the A/D Converter, the component side of the scanner should face the component side of the A/D Converter.

7. Replace the rear panel.

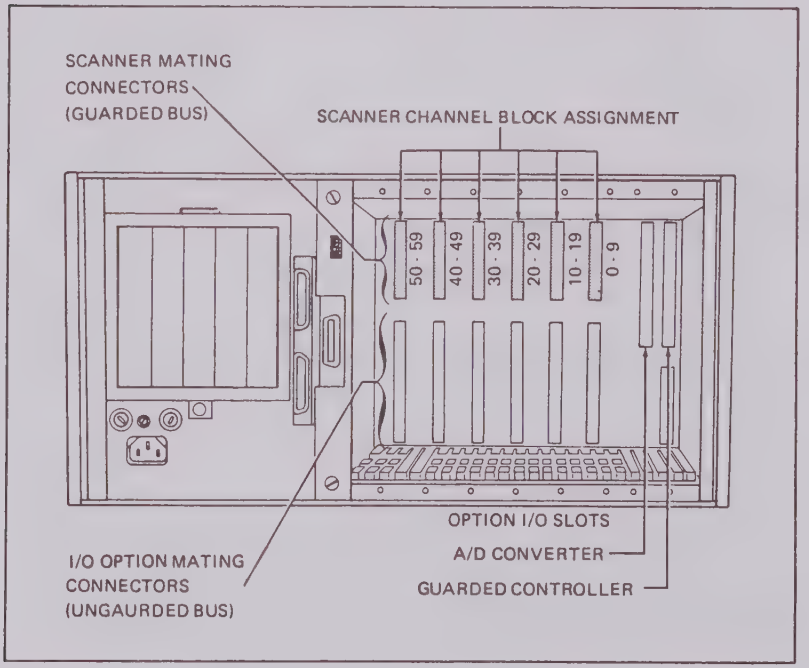


Figure 109-1. Installation Location

Operation

Once installed in a chassis, the A/D Converter Option is ready for operation. External wiring connections necessary to provide the A/D Converter with analog inputs are made by using signal conditioners, the appropriate scanners, and input connectors. Table 109-2 shows the possible hardware combinations useable with the 2400A-109 A/D Converter.

Table 109-2. Possible Hardware Combinations

Signal Conditioner	Scanner	Input Connector
None Needed	2400A-101 High Performance Scanner	2400A-102 Isothermal Input Connector 2400A-106 Current Input Connector 2400A-108 Voltage Input Connector 2400A-119 AC Volts Input Connector
2400A-701 RTD, Ohms, Quarter-Bridge, Half-Bridge, Signal Conditioner	2400A-115 Four-Wire Scanner 2400A-117 Six-Wire Scanner	2400A-116 Four-Wire Input Connector 2400A-118 Six-Wire Input Connector
2400A-702 Half-, Full-Bridge Strain Signal Conditioner	2400A-117 Six-Wire Scanner	2400A-118 Six-Wire Input Connector

By using 2401A Scanner Extender chassis, scanners may be added to obtain a maximum of 1000 analog input channels. Refer to the 2401A Operation Manual and the appropriate option subsections of this guide for descriptions of the use of the analog input options.

The Analog-to-Digital (A/D) Converter is the most versatile of the 2400B Input/Output Options. There are many 2400B commands that affect the A/D Converter. Through the 2400B Intelligent Computer Front End command set, the A/D speed, maximum range, autorange enable and disable, and sensor type may be selected. Additional capabilities may be realized by using signal conditioners and by taking advantage of the inherent pipeline nature of the A/D, allowing channel scanning at high speed. To fully exercise these capabilities, see the 2400B Programming Guide for full details of the analog input measurement function of the 2400B.

Installation Verification Test

To verify proper A/D installation, check the two A/D Self-Test voltages. This requires no additional equipment set up. Refer to the Programming Guide for a description of the 2400B commands used below.

1. Apply power to the 2400B by depressing the front panel POWER switch.

2. Addressing the 2400B through the host device, enter the following command:

```
SEND STI(0) !
```

3. Verify that the value sent by the 2400B equals 0.095 volts, +/- 0.0003 volts.

4. Enter the command:

```
SEND STI(1) !
```

5. Verify that the self test voltage equals 6.3 volts, +/- 0.015 volts.

6. Failure of any of these steps could mean either improper installation or a defective A/D Converter.

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation, can be found in the 2400B Service Manual.

OPTION 2400A-115 FOUR-WIRE SCANNER

Description

The Four-Wire Scanner (Option 2400A-115) is a plug-in 10-channel, 4-wire, vacuum-reed relay scanner. It operates as a low-level analog data multiplexer linking external measurement points through the RTD, Ohms, Quarter-Bridge, or Half-Bridge Signal Conditioner (Option 2400A-701) to the A/D Converter (Option 2400A-109).

The Four-Wire Scanner consists of a single printed circuit board assembly that mounts in any of the I/O option slots in the 2400B or 2401A chassis. The signal conditioner and A/D converter used with the scanner must reside in the 2400B chassis.

The scanner transmits excitation signals from the signal conditioner through the input connector to external measurement points. The response signals from the external measurement points are transmitted through the input connector, scanner, and signal conditioner to the input of the A/D converter. Input voltages and output currents are applied through a 44-pin card-edge connector on the Four-Wire Input Connector (Option 2400A-116).

Channel address blocks are allocated to each I/O option slot in a chassis. Figure 115-1 shows the analog input channels assigned to each I/O option slot. The Four-Wire Scanner specifications are listed in Table 115-1.

Installation

The Four-Wire Scanner mounts in any available I/O option slot in the 2400B or 2401A chassis. Referring to Figure 115-2, install the scanner as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connector cables from the chassis.

3. Remove the rear panel from the chassis.

Caution

Handle the scanner assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. To select the best I/O option slot for mounting the scanner, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

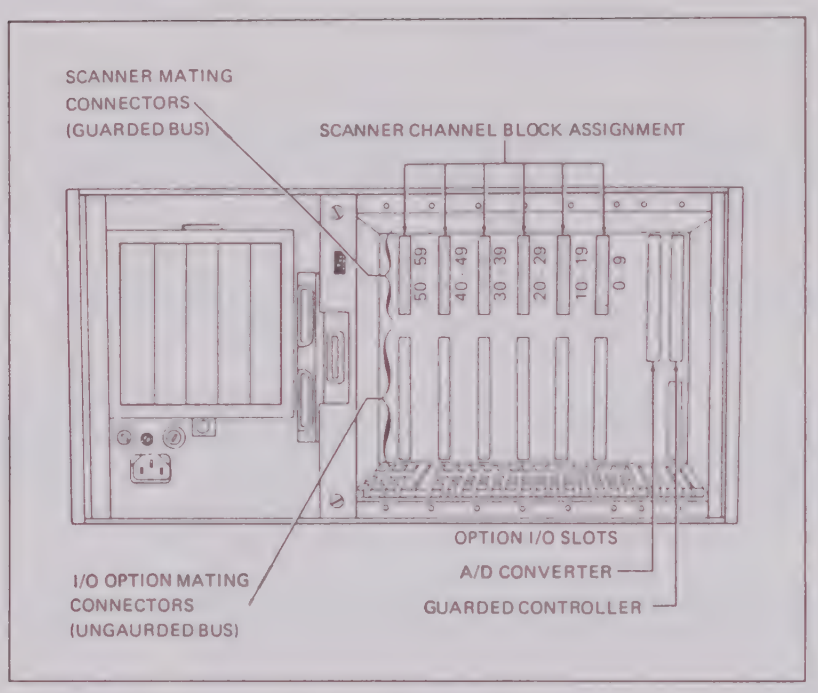


Figure 115-1. Scanner Channel Locations

Table 115-1. Four-Wire Scanner Specifications

NUMBER OF CHANNELS	10 per assembly
MAXIMUM NUMBER OF CHANNELS	990 (a maximum of 99 assemblies in an extended system)
CHANNEL RELAYS	40 reed relays
POLES PER CHANNEL	4 (2 source, 2 sense)
VOLTAGE OFFSET (THERMAL UNCERTAINTY)	Less than or equal to 1 μV
MAXIMUM INPUT VOLTAGE LIMIT (COMMON MODE AND/OR NORMAL MODE)	Up to 250V rms or 250V dc from any channel to any other channel or ground and 30V between terminals on any channel.
WEIGHT	0.7 kg (1.5 lb)
ENVIRONMENTAL	Meets all the environmental specifications of the 2400

5. Align the scanner in its slot so that its offset card-edge connector is toward the front of the unit and the large card-edge connector is toward the rear of the unit as shown in Figure 115-2. Push the scanner onto the chassis mating connector.

6. Rotate the plastic locking tabs located on the top and bottom of the pcb until they click into place.

7. Reinstall the connectors and cables removed in Step 2.

8. Reinstall the rear panel, removing the scanner-cover sections as necessary.

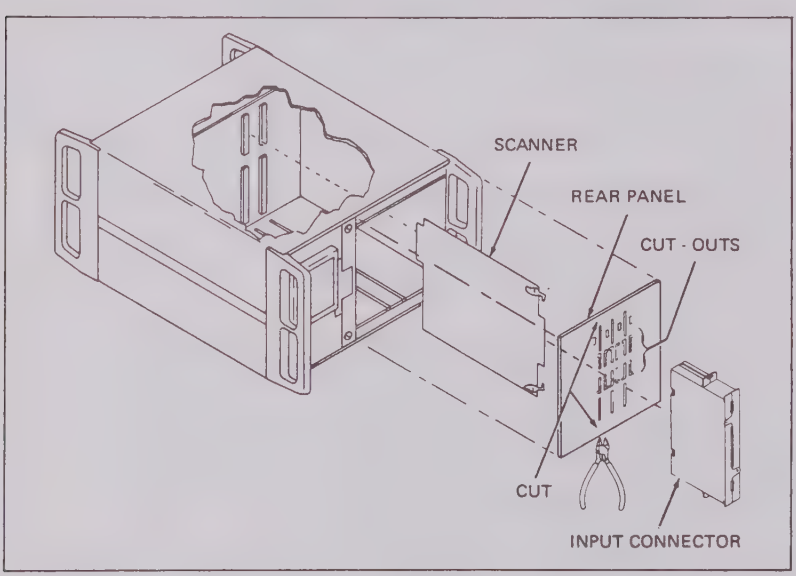


Figure 115-2. Scanner Mounting Location

Operation

Once installed in the chassis, the Four-Wire Scanner is ready for use. The user must complete wiring connections from the scanner to the external measurement points, using the Four-Wire Input Connector. External measurement connections are made to the 2400A-116 Four-Wire Input Connector Assembly, which then mates with the connector on the scanner. Refer to the section on Option 2400A-116 for a description of the input connector.

Note

The 2400B command set operates the Four-Wire Scanner. Refer to the Programming Guide for an explanation of the scanner commands.

Installation Verification Test

To verify proper installation of the scanner, set up and sample a single scanner channel using a RTD, Ohms, Quarter-Bridge, Half-Bridge Signal Conditioner (2400A-701), a Four-Wire Input Connector (2400A-116), and a resistor. For this test you will need a 10 ohm and a 1000 ohm precision resistor. Refer to Figure 115-3 for connection details. Use the following procedure to verify operation of the scanner:

1. Connect the 10 and 1000 ohm resistors to the Four-Wire Input Connector as Figure 115-3 shows.

2. Install the connector to the scanner as described in the section on Option 2400A-116.

3. Apply power to the 2400B by depressing the front panel POWER switch.

4. Send the following definition to the 2400B:

```
DEFN
AICHAN = <first channel #>, SENSOR = OHMS, SIGCND = x4;
AICHAN = <second channel #>, SENSOR = OHMS, SIGCND= x0;
!
```

(x = the slot number where the RTD, Ohms, Quarter-Bridge, or Half-Bridge Signal Conditioner resides)

5. Send the following command to the 2400B:

```
SEND AI(first channel #) !
```

6. Verify that the value returned by the 2400B equals 10 (plus or minus the tolerance of the resistor).

7. Send the following command to the 2400B:

```
SEND AI(second channel #) !
```

8. Verify that the value returned by the 2400B equals 1000 (plus or minus the tolerance of the resistor).

9. This completes the installation verification test. Turn power off and remove all test connections.

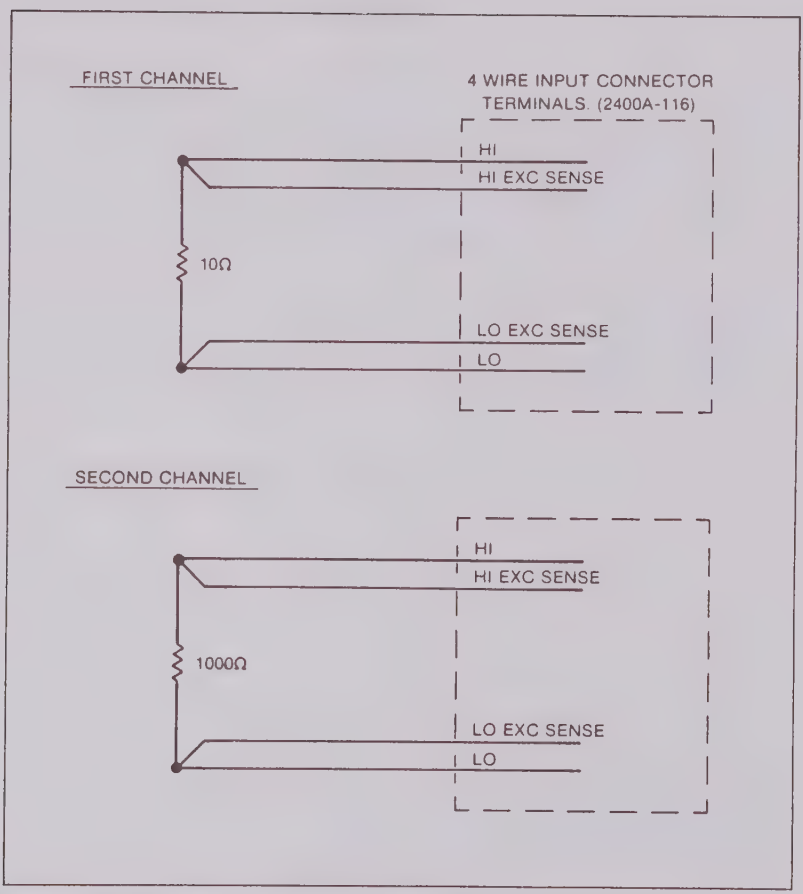


Figure 115-3. Installation Verification Test Wiring Diagram

Service Information

Troubleshooting procedures, parts lists, schematics, and theory of operation are given in the 2400B Service Manual.

OPTION 2400A-116 FOUR-WIRE INPUT CONNECTOR

Description

The Four-Wire Input Connector Assembly is a card-edge connector assembly that allows up to ten resistive devices to be connected to the Four-Wire Scanner (Option 2400A-115). The connector allows measurement of RTD's and quarter-bridge strain gauges, and other resistances. The Four-Wire Input Connector mounts on the back of the Four-Wire Scanner Assembly in a 2400B or 2401A Scanner Extender chassis. Specifications for the Four-Wire Input Connector are given in Table 116-1.

Input and output connections are made using screw terminals, with four terminals per channel (HI, LO, HI EXC SENSE, LO EXC SENSE) as Figure 116-1 shows. Up to ten inputs can be assigned to each Four-Wire Input Connector Assembly. Connection to the scanner is through a 44-pin edge connector. The entire Four-Wire Input Connector assembly is encased in a plastic clamshell housing.

Table 116-1. Four-Wire Input Connector Specifications

CONNECTOR TYPE	Four-wire input
COMPATIBILITY	Mates with 2400A-115 Four-Wire Scanner Assembly
NUMBER OF INPUTS	10 per assembly
NUMBER OF TERMINALS	Four per channel, 40 terminals per assembly.
TERMINAL STYLE	Screw type
MAXIMUM COMMON MODE VOLTAGE	250V rms, or 250V dc between any channel and any other channel or ground and 30V between terminals on any channel when used with the 4-Wire Scanner (2400A-115).
WEIGHT	0.4 kg (1 lb)

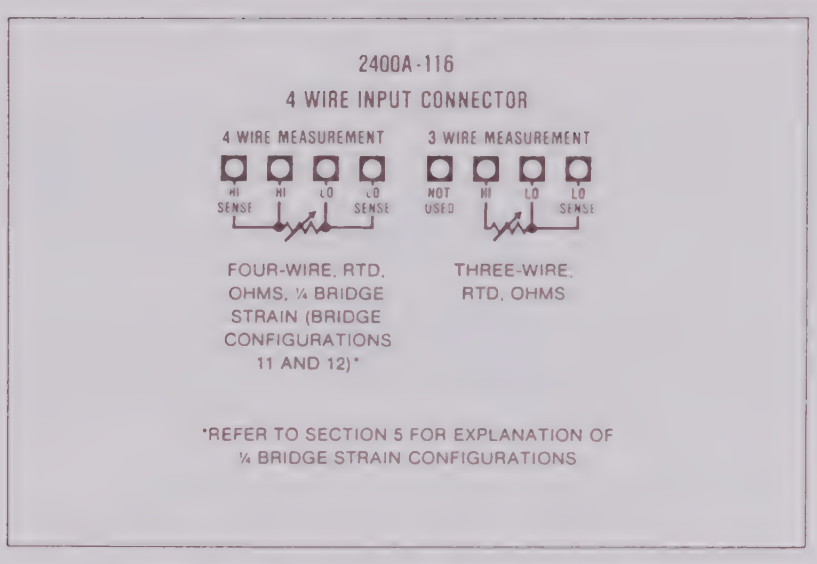


Figure 116-1. Four-Wire Input Connector Wiring

Installation

The Four-Wire Input Connector mounts in any available I/O option slot containing a Four-Wire Scanner. Referring to Figure 116-2, install the connector as follows:

1. Set the chassis POWER switch to OFF.

2. Locate the desired I/O option slot on the rear panel and check to ensure that a scanner pcb is installed in the slot.

3. Separate the halves of the clamshell by gently prying apart the locking tabs with your fingers.

4. Starting with channel 0 (refer to Figure 116-1 or the decal on the clamshell side), attach external wiring as necessary for your application. Be sure that no voltages exist on the external wires before connecting them to the connector.

WARNING

USE OF AN OVERSIZED SCREWDRIVER MAY DAMAGE THE TERMINAL BLOCK. DAMAGED OR DIRTY TERMINAL BLOCKS MAY NOT STAND OFF THE RATED VOLTAGE.

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key to the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws that hold the input connector to the chassis rear panel.

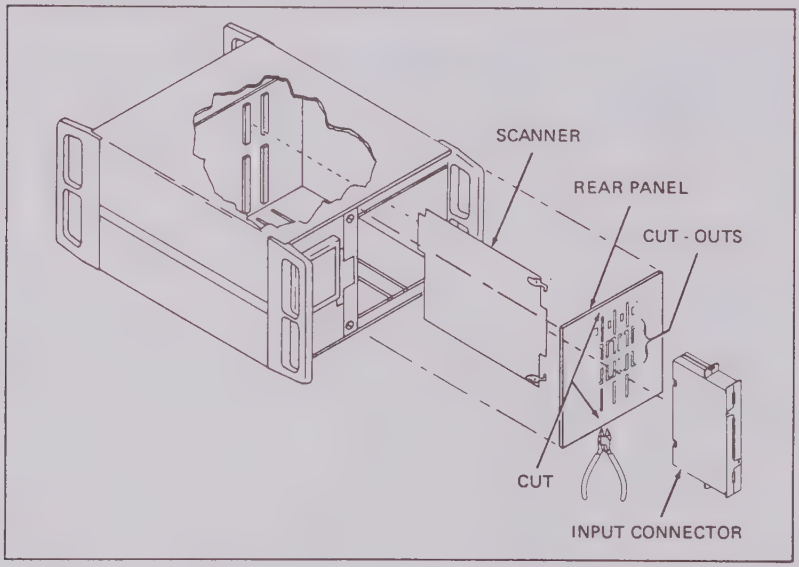


Figure 116-2. Connector and Scanner Mounting Locations

Operation

Once installed in the chassis, the Four-Wire Input Connector is ready for use and requires no operator attention.

Installation Verification Test

Correct Four-Wire Input Connector installation can be verified by installing the connector on a 2400A-115 Four-Wire Scanner assembly and performing the Four-Wire Scanner verification test given in the section on Option 2400A-115.

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation, can be found in the 2400B Service Manual.

OPTION 2400A-117 SIX-WIRE SCANNER

Description

The Six-Wire Scanner (Option 2400A-117) is a plug-in, five-channel, six-wire, vacuum-reed relay scanner. It operates as a low-level analog data multiplexer linking external measurement points through the Half-, Full-Bridge Strain Signal Conditioner (Option 2400A-702) or the RTD, Ohms, Quarter-Bridge, Half-Bridge Signal Conditioner (Option 2400A-701) to the A/D Converter (Option 2400A-109).

The Six-Wire Scanner is a printed circuit board assembly that mounts in any of the I/O option slots. The scanner transmits excitation signals from the signal conditioner to the input connector and transmits the response voltage to the input of the A/D converter. Input and output voltages are applied through a 44-pin card-edge connector that resides on the Six-Wire Input Connector (Option 2400A-118).

The Six-Wire Scanner Assembly may reside in the 2400B or 2401A Scanner Extender chassis. The signal conditioner and A/D converter used with the scanner must reside in a 2400B chassis.

Channel addresses are determined by the choice of the I/O option slot. Figure 117-1 shows the analog input channel blocks assigned to the I/O Option slots. The Six-Wire Scanner responds only to even numbered addresses. For example, if a Six-Wire Scanner is in slot 2, channels 20, 22, 24, 26, and 28 could be read. If the other channels are referenced, undefined results will be returned to the user by the 2400B.

Specifications for the Six-Wire Scanner are given in Table 117-1.

Table 117-1. Six-Wire Scanner Specifications

NUMBER OF CHANNELS	5 per assembly. Channels are numbered 0, 2, 4, 6, 8
MAXIMUM NUMBER OF CHANNELS	495 (a maximum of 99 assemblies in an extended system)
CHANNEL RELAYS	30 reed relays.
POLES PER CHANNEL	6 (2 source, 4 sense)
VOLTAGE OFFSET (THERMAL UNCERTAINTY)	Less than or equal to 1 μV.
MAXIMUM INPUT VOLTAGE LIMIT (COMMON MODE AND/OR NORMAL MODE)	Up to 250V rms or 250V dc between any channel and any other channel or ground and 30V between terminals on any channel.
WEIGHT	0.9 kg (2 lb)
ENVIRONMENTAL	Meets all the environmental specifications of the 2400

Installation

The Six-Wire Scanner mounts in any available I/O option slot in the 2400B or 2401A chassis, as Figure 117-2 shows. Install the scanner as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connector cables from the chassis.

3. Remove the rear panel from the chassis.

Caution

Handle the scanner assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

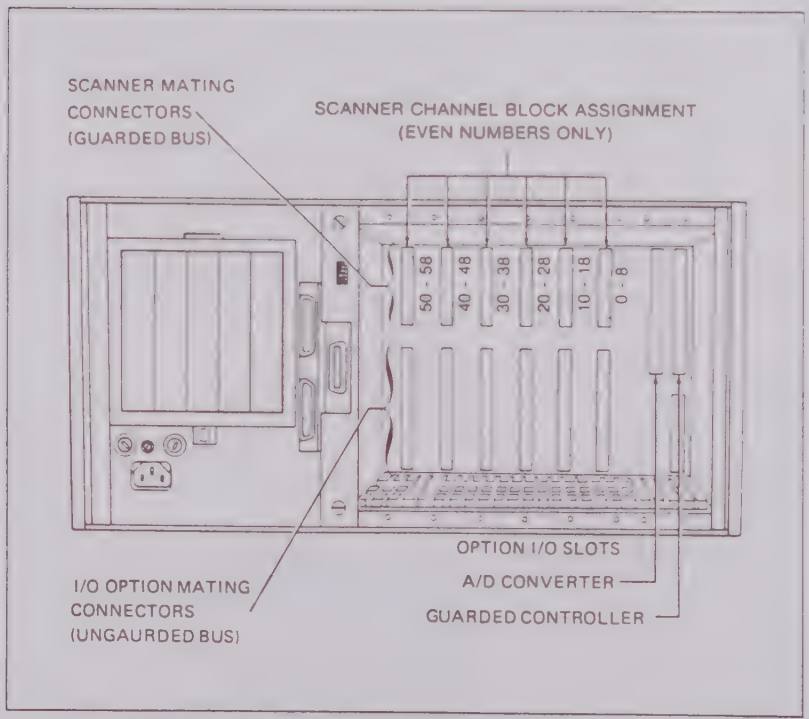


Figure 117-1. Scanner Channel Locations

4. To select the best I/O option slot for mounting the scanner, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the scanner in its slot so that its offset card-edge connector is toward the front of the unit and the large card-edge connector is toward the rear of the unit as shown in Figure 117-2. Push the scanner into the chassis mating connector.

6. Rotate the plastic locking tabs located on the top and bottom of the pcb until they click into place.

7. Replace the connectors and cables removed in Step 2.

8. Replace the rear panel, removing the scanner-cover sections as necessary.

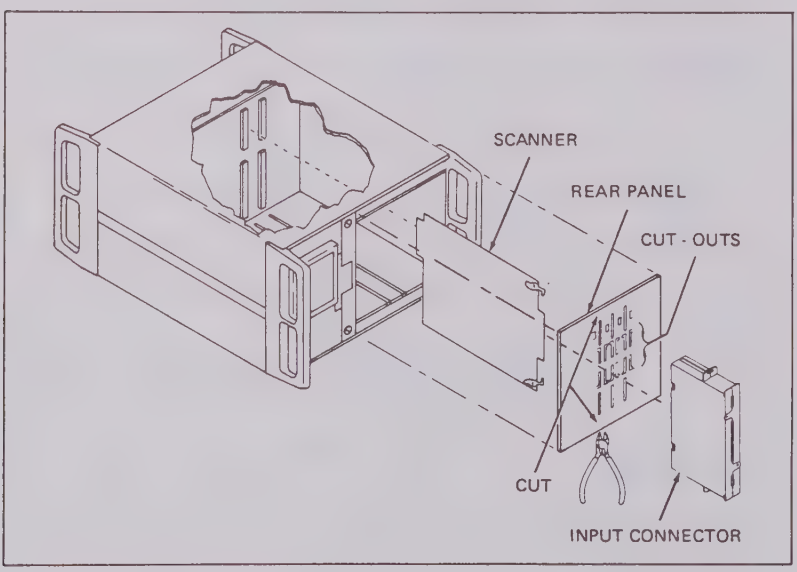


Figure 117-2. Scanner Mounting Location

Operation

Once installed in the chassis, the Six-Wire Scanner is ready for use. The user must complete wiring connections from the scanner to the external measurement points. Refer to the section on Option 2400A-118 for a description of the Six-Wire Input Connector.

Note

The 2400B command set operates the Six-Wire Scanner. Refer to the 2400B Programming Guide for an explanation of the scanner commands.

Installation Verification Test

To verify proper installation of the scanner, set up and sample a single scanner channel using a Half-, Full-Bridge Strain Signal Conditioner (2400A-702), a Six-Wire Input Connector (2400A-118), and a resistor bridge as shown in Figure 117-3. For this test you will need four 120 ohm precision resistors and one 5900 ohm precision resistor. Use the following procedure to verify operation after the hardware has been set up:

1. Connect the bridge to the Six-Wire Input Connector as shown in Figure 117-3, leaving one end of the 5900 ohm resistor disconnected.

2. Install the connector to the scanner as described in the section on Option 2400A-118, except leave the clamshell open.

3. Apply power to the 2400B by depressing the front panel POWER switch.

4. Send the following definition to the 2400B:

```
DEFN
AICHAN = <channel #>, SENSOR = STRAIN, BRCONF = 3,
SIGCND =x0, EXVOLT = 4, RNOM = 120;
!
```

   (x = the slot where the 2400A-702 signal conditioner resides)

5. Send the following commands to the 2400B:

```
CSINIT(channel #)!
SEND AI(channel #)!
```

6. Verify that the value returned by the 2400B equals 0 (plus or minus five microstrain).

7. While the 2400B is powered-up, connect the 5900 ohm bridge offset resistor as Figure 117-3 shows.

8. Send the following command to the 2400B:

```
SEND AI(channel #)!
```

9. Verify that the value returned by the 2400B equals 5000 microstrain (plus or minus 100 microstrain).

10. This completes the installation verification test. Turn power off and remove test connections.

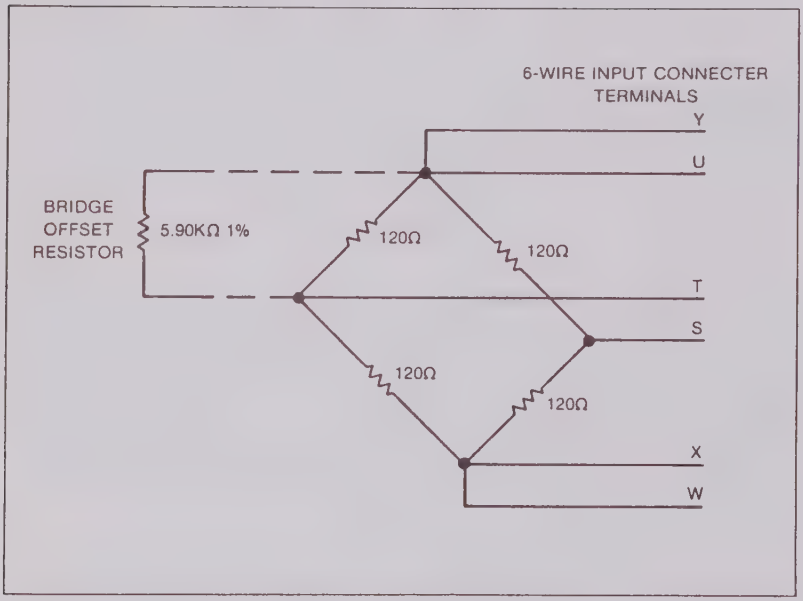


Figure 117-3. Installation Verification Test Wiring Diagram

Service Information

Troubleshooting procedures, parts lists, schematics, and theory of operation are given in the 2400B Service Manual.

OPTION 2400A-118 SIX-WIRE INPUT CONNECTOR

Description

The Six-Wire Input Connector Assembly is a card-edge connector assembly that allows up to five resistance bridge devices to be connected to the Six-Wire Scanner (Option 2400A-117). The connector allows measuring of half- or full-bridge strain gauges, and resistance bridge transducers. The Six-Wire Input Connector mounts on the back of the Six-Wire Scanner Assembly in a 2400B or 2401A chassis.

Specifications for the Six-Wire Input Connector are given in Table 118-1.

Input and output connections are made using screw terminals, with six terminals per channel (S, T, U, W, X, and Y, with V and Z unconnected) as Figure 118-1 shows. The various ways that a resistance bridge can be connected to the terminals are shown in Figure 118-1. Up to five inputs can be assigned to each Six-Wire Input Connector Assembly. Connection to the scanner is through a 44-pin edge connector. Table 118-2 gives the connector letter designations and descriptions of the associated signals. The entire Six-Wire Input Connector assembly is housed in a plastic clamshell housing.

Table 118-1. Six-Wire Input Connector Specifications

CONNECTOR TYPE	Six wire input
COMPATIBILITY	Mates with a 2400A-117 Six-Wire Scanner Assembly.
NUMBER OF INPUTS	Five per assembly
NUMBER OF TERMINALS	Six per channel, 30 terminals per assembly.
TERMINAL STYLE	Screw type
MAXIMUM COMMON MODE VOLTAGE	250V rms, or 250V dc between any channel and any other channel or ground and 30V between terminals on any channel when used with the Six-Wire Scanner (2400A-117).
WEIGHT	0.4 kg (1 lb)

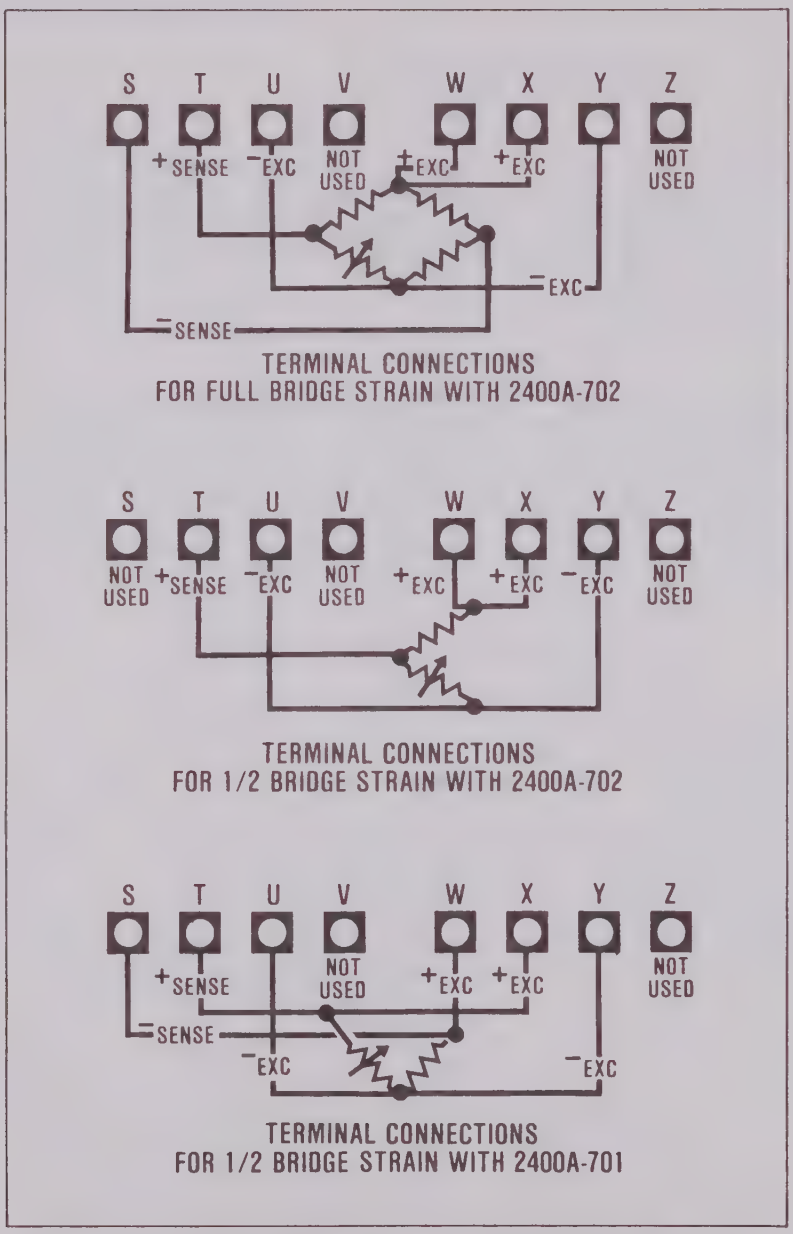

S T U V W X Y Z
+SENSE −EXC NOT USED ±EXC +EXC NOT USED
−EXC
−SENSE
TERMINAL CONNECTIONS
FOR FULL BRIDGE STRAIN WITH 2400A-702
S T U V W X Y Z
NOT USED +SENSE −EXC NOT USED +EXC +EXC −EXC NOT USED
TERMINAL CONNECTIONS
FOR 1/2 BRIDGE STRAIN WITH 2400A-702
S T U V W X Y Z
+SENSE NOT USED +EXC +EXC NOT USED
−SENSE
−EXC
−EXC
TERMINAL CONNECTIONS
FOR 1/2 BRIDGE STRAIN WITH 2400A-701

Figure 118-1. Six-Wire Input Connector Terminal Arrangement

Table 118-2. Terminal Letter Designations

Connector Designator	Signal Name
S	Low input to the A/D converter
T	High input to the A/D converter
U	Low excitation sense input
V	No connection
W	High excitation sense input
X	High excitation output
Y	Low excitation output
Z	No connection

Installation

The Six-Wire Input Connector mounts in any available I/O option slot containing a Six-Wire Scanner (see Figure 118-2). Install the connector as follows:

1. Set the chassis POWER switch to OFF.

2. Locate the desired I/O option slot on the rear panel and check to make sure that a scanner pcb is installed in the slot.

3. Separate the halves of the clamshell by gently prying open the locking tabs with your fingers.

4. Starting at channel 0, attach external wiring as necessary for your application. Refer to Figure 118-3 for wiring connections to various bridge configurations. Be sure that no voltages exist between any wires before connecting them to the connector.

WARNING

USE OF AN OVERSIZED SCREWDRIVER MAY DAMAGE THE TERMINAL BLOCK. DAMAGED OR DIRTY TERMINAL BLOCKS MAY NOT STAND OFF THE RATED VOLTAGE.

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key to the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws that hold the input connector to the chassis rear panel.

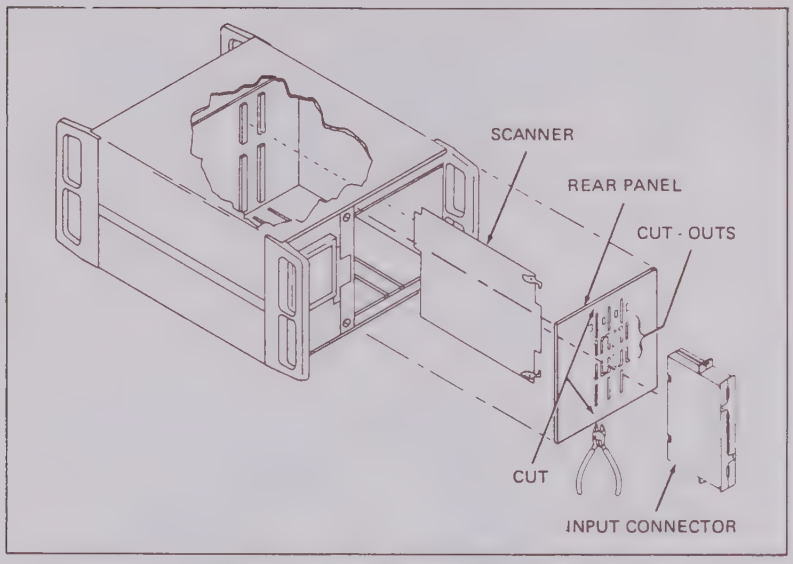


Figure 118-2. Connector and Scanner Mounting Locations

Operation

Once installed in the chassis, the Six-Wire Input Connector is ready for use and requires no operator attention.

Installation Verification Test

Correct Six-Wire Input Connector installation can be verified by installing the connector on a Six-Wire Scanner Assembly (2400A-117) and performing the Six-Wire Scanner Assembly verification test (see the section on Option 2400A-117).

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation, can be found in the 2400B Service Manual.

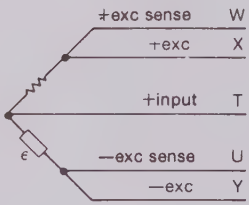
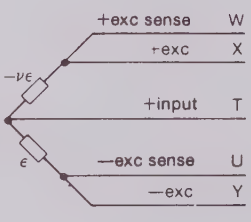
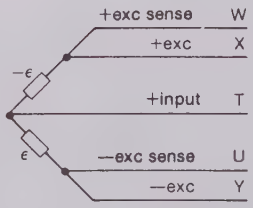
BRIDGE CONFIGURATION NUMBER (BRCONF)	DESCRIPTION
0	 ½ bridge configuration, voltage excited. Single active strain gage.
1	 ½ bridge configuration, voltage excited. Two active strain gages, one aligned with maximum principal strain, one aligned with Poisson strain.
2	 ½ bridge configuration, voltage excited. Two strain gages, both active with equal and opposite strains.

Figure 118-3. Bridge Configurations

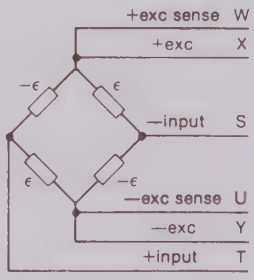
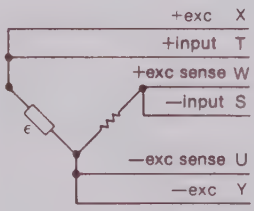
BRIDGE CONFIGURATION NUMBER (BRCONF)	DESCRIPTION
9	 Full bridge configuration, voltage excited. Four active strain gages, with pairs subjected to equal and opposite strains.
10	 ½ bridge configuration, current excited. One active strain gage.

Figure 118-3. Bridge Configurations (cont.)

OPTION 2400A-119 AC VOLTS INPUT CONNECTOR

Description

The AC Volts Input Connector is a card-edge connector that allows the High-Performance Scanner (Option 2400A-101) to be used for making ac voltage measurements in the 5V to 250V range. The AC Volts Input Connector accepts ac voltage inputs from external sources and converts them to proportional dc voltages for application to the associated scanner. The dc voltages produced by the AC Volts Input Connector equal the rms value of the ac inputs divided by 1000. The conversion of each input is done by a diode, a precision divider network, and a filter.

The voltage applied to any channel of the input connector must be less than 250V rms. Nominal frequency range for ac inputs is 45 Hz to 450 Hz.

Up to 10 inputs can be assigned to each AC Voltage Input Connector. Input connections are made using screw terminals, with two terminals per input. Figure 119-1 shows the connector decal and the assignment of the connector terminals. Connection of the AC Volts Input Connector to the scanner is through a 44-pin edge connector. Specifications for the AC Voltage Input Connector are given in Table 119-1.

Installation

The AC Voltage Input Connector mounts in any available I/O option slot containing a High Performance Scanner. Referring to Figure 119-2, install the connector as follows:

1. Set the chassis POWER switch to OFF.

2. Locate the desired I/O option slot on the rear panel and check to make sure that a scanner PCB assembly is installed in the slot.

3. Separate the halves of the clamshell by gently prying apart the locking tabs with your fingers.

WARNING

BEFORE CONNECTING EXTERNAL WIRING TO THE AC VOLTAGE INPUT CONNECTOR, REMOVE ALL SOURCE VOLTAGES FROM THE WIRING.

4. Starting at channel 0, attach the external wiring required for your application. Use twisted pair solid wire.

WARNING

USE SOLID WIRE, NOT STRANDED. IF STRANDED WIRE IS USED, STRAY STRANDS MAY REDUCE HIGH VOLTAGE SPACING BETWEEN HI/LO TERMINALS.

Caution

To avoid damage to the terminal block, use the proper size screwdrivers.

Handle the pcb by its edges to avoid contaminating it with dirt or oil from the hands. The use of gloves is recommended. A damaged or dirty terminal block or contaminated pcb may not stand off its rated voltage.

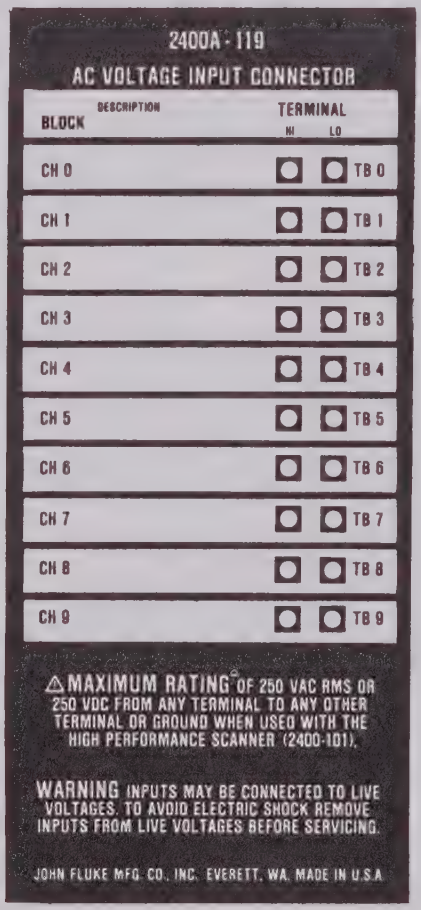


Figure 119-1. Voltage Input Connector Terminal Locations

5. Reassemble the halves of the clamshell, making sure the external wires are not pinched where they exit the rear of the enclosure.

6. With the card-edge connector key at the top, insert the connector in the I/O option slot guides until it mates with the scanner connector.

7. Install the two retaining screws that hold the input connector to the chassis rear panel.

CONNECTOR TYPE	AC voltage input connector.
COMPATIBILITY	Mates with a Model 2400A-101 High Performance Scanner.
NUMBER OF INPUT CHANNELS ...	10 per assembly connector.
NUMBER OF TERMINALS	Two per channel, 20 terminals per connector.
TERMINAL STYLE	Screw type
NORMAL RANGE	5V rms to 250V rms
INPUT RESISTANCE	1 Megohm
CONVERSION METHOD	½ wave, average responding, calibrated to indicate the rms value of a sine wave.
MAXIMUM COMMON MODE VOLTAGE	250V rms, or 250V dc between any terminal and any other terminal and/or ground.
WEIGHT	0.4 kg (1 lb.)
ACCURACY OF MEASUREMENT ..	±(1.0% of input +0.1 volt)

NOTE: The AC Voltage Input Connector uses 1000:1 attenuation to obtain a dc output which is 1/1000th of the ac input.

Table 119-1. AC Volts Input Connector Specifications

Operation

Once installed in the chassis, the AC Voltage Input Connector requires no operator attention. The 2400B command set operates the scanner associated with the AC Voltage Input Connector. Refer to the Programming Guide for explanation of 2400B commands and more details of scanner operation.

Installation Verification Test

Correct AC Voltage Input Connector installation can be verified by installing the connector on a High Performance Scanner assembly (2400A-101) and sampling a single channel using a known ac voltage source (such as produced by a calibrator) as the input to that channel. For this test you will need an AC voltage calibrator. Test one scanner channel as follows:

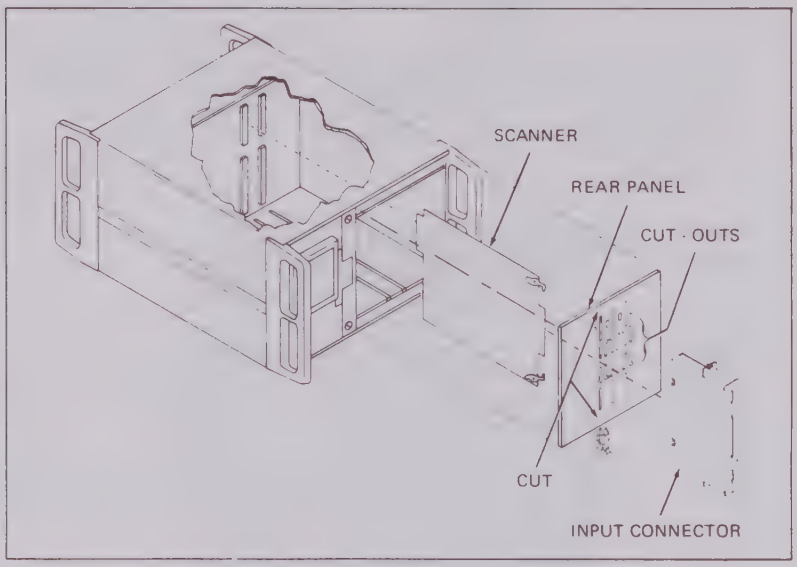


Figure 119-2. Connector and Scanner Mounting Locations

1. Set the ac calibrator output to 0 volts.

2. Connect a channel of the input connector to the output terminals of the calibrator (HI to positive and LO to negative).

3. Install the connector on the scanner as previously described.

4. Apply power to the 2400B by depressing the front panel POWER switch.

5. At the host device, address the 2400B by entering the following command:

```
DEFN
AICHAN = <channel #>, SENSOR = ACVOLT;
!
```

Where "channel #" is the analog input channel number under test.

6. Set the calibrator output to any voltage between 5 and 250V ac rms.

7. Enter the command:

```
SEND AI(channel #)!
```

8. Verify that the voltage value returned to the host device is the same as that selected on the ac calibrator, plus or minus calibrator error, plus or minus the accuracy of the AC Volts Input Connector.

9. Repeat Steps 1 through 7 for each of the remaining nine inputs of the AC Volts Input Connector to complete the verification test.

Service Information

Service and calibration information, including schematics, parts lists, and theory of operation, can be found in the 2400B Service Manual.

OPTION 2400A-701 RTD/OHMS/QUARTER-HALF BRIDGE CONDITIONER

Description

The RTD/Ohms/Quarter-Half Bridge Strain Signal Conditioner Option (2400A-701) is an assembly that provides precision excitation currents, (100 uA, 1 mA, or 10 mA) for RTD and resistance measurements. The signal conditioner also provides dual tracking 10 mA current sources for quarter-bridge strain and half bridge strain measurements. Refer to Table 701-1 for a list of signal conditioner specifications.

Table 701-1. Signal Conditioner Specifications

RESISTANCE MEASUREMENT ACCURACY

RESISTANCE RANGE (Ohms)	CURRENT (mA)	A/D RANGE (Volts)	RESOLUTION (Ohms)	RATE (rdgs. per sec.)	FOUR-WIRE ACCURACY ±(% of Reading + Ohms)	
					90 days	1 year
0-64k	0.1	6.4	1.0	30	0.021 + 5	0.036 + 7
0-8k	0.1	0.8	0.1	30	0.021 + 0.6	0.036 + 0.8
0-4k	0.1	0.8	0.1	3*	0.021 + 0.5	0.036 + 0.7
0-4k	0.1	0.8	0.1	30	0.021 + 0.6	0.036 + 0.8
0-800	1.0	0.8	0.01	3	0.021 + 0.05	0.036 + 0.07
0-800	1.0	0.8	0.01	30	0.021 + 0.06	0.036 + 0.08
0-100	1.0	0.1	0.001	3	0.021 + 0.008	0.036 + 0.012
0-100	1.0	0.1	0.001	30	0.021 + 0.011	0.036 + 0.015
0-10	10.0	0.1	0.0001	3	0.021 + 0.0008	0.036 + 0.0012
0-10	10.0	0.1	0.0001	30	0.021 + 0.0011	0.036 + 0.0015

* If resistance of greater than 4KΩ are measured at three readings per second, inaccuracies may result.

Other ranges and combinations of ranges can be used depending upon the particular applications. For resistance measurements using current and A/D ranges other than those specified above, refer to System Accuracy for Four-Wire Measurements and System Accuracy for Three-Wire Measurements.

ABSOLUTE ACCURACY OF
CURRENT SOURCES ..... ±0.005% at calibration, 21-25°C

TEMPERATURE COEFFICIENT
OF CURRENT SOURCES ..... 10PPM/°C

Table 701-1. Signal Conditioner Specifications (cont.)

SYSTEM ACCURACY — FOUR-WIRE MEASUREMENTS

RESISTANCE RANGE (Ohms)	CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading in ohms + counts + microvolts)
0-4k	24 hours, 21-25°C	3	0.01 + 3 + 4
0-64k	24 hours, 21-25°C	30	0.01 + 5 + 6
0-4k	90 days, 18-28°C	3	0.021 + 4 + 4
0-64k	90 days, 18-28°C	30	0.021 + 5 + 6
0-4k	1 year, 13-33°C	3	0.036 + 6 + 6
0-64k	1 year, 13-33°C	30	0.036 + 7 + 8

The A/D Converter range used determines the microvolt value of one count: if maximum input voltage to the A/D Converter is 0.1V, one count is equal to 1 microvolt; if maximum input is 0.8V, one count is equal to 10 micro-volts; if maximum input is 6.4V, one count is equal to 100 microvolts.

To convert the above specifications to ohms, divide (the number of counts in microvolts plus the number of microvolts) by the excitation current value in microamperes then add to (% of reading) X (actual reading).

$$\frac{\text{(counts in microvolts + microvolts)}}{\text{excitation current}} + \text{(\% of reading)(reading)}$$

TEMPERATURE COEFFICIENT OF SYSTEM - FOUR-WIRE MEASUREMENTS ..... ±(0.002% of reading + 0.2 counts)/°C

SYSTEM ACCURACY — THREE-WIRE MEASUREMENTS

RESISTANCE RANGE (Ohms)	CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading in ohms + counts + microvolts)
0-4k	24 hours, 21-25°C	3	0.01 + 4 + 0.21
0-64k	24 hours, 21-25°C	30	0.01 + 5 + 6 + 0.21
0-4k	90 days, 18-28°C	3	0.021 + 4 + 13 + 0.21
0-64k	90 days, 18-28°C	30	0.021 + 6 + 15 + 0.21
0-4k	1 year, 13-33°C	3	0.036 + 6 + 42 + 0.21
0-64k	1 year, 13-33°C	30	0.036 + 7 + 43 + 0.21

The three-wire accuracy specifications apply if one channel per scanner is shorted and used as an offset. If this offset adjusting scheme is not used, add ±0.35 ohms to the above specifications.

The A/D Converter range used determines the value of one count: if maximum input voltage to the A/D Converter is 0.1V, one count equals 1 microvolt; if maximum input is 0.8V, one count equals 10 microvolts; if maximum input is 6.4V, one count equals 100 microvolts.

To convert the above specifications to ohms, divide (the number of counts in microvolts plus the number of microvolts) by the excitation current value in microamperes then add to (% of reading) X (actual reading).

$$\frac{\text{(counts in microvolts + microvolts)}}{\text{excitation current}} + \text{(\% of reading)(reading)}$$

Table 701-1. Signal Conditioner Specifications (cont.)

TEMPERATURE COEFFICIENT OF SYSTEM - THREE-WIRE MEASUREMENTS ..... ±(0.002% of reading + 0.2 counts + 2.5 uV/°C)

100-OHM RTD ACCURACY (FOUR-WIRE: ASSUMES RTDALP = 0.00385, CURRENT = 1 mA, A/D RANGE = 0.8V, A/D RATE = 3 RDGS/SEC, 90 DAYS) ±0.3°C at 0°C, ±0.4°C at 600°C

QUARTER BRIDGE STRAIN (USING 0.1V A/D RANGE, 10mA CURRENT SOURCE)

Rgage = 350 Ohms

RESOLUTION ..... 0.2 microstrain

TEMPERATURE COEFFICIENT.. ±5.2 $\mu\epsilon$/°C

SYSTEM ACCURACY

CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading + microstrain)
24 hours, 21-25°C	3	0.02 + 2.1
24 hours, 21-25°C	30	0.02 + 2.6
90 days, 18-28°C	3	0.042 + 13.5
90 days, 18-28°C	30	0.042 + 13.7
1 year, 13-33°C	3	0.072 + 26.8
1 year, 13-33°C	30	0.072 + 27.0

Rgage = 120 Ohms

RESOLUTION ..... 0.5 microstrain

TEMPERATURE COEFFICIENT.. ±5.5 $\mu\epsilon$/°C

SYSTEM ACCURACY

CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading + microstrain)
24 hours, 21-25°C	3	0.02 + 5.7
24 hours, 21-25°C	30	0.02 + 7.0
90 days, 18-28°C	3	0.042 + 15.7
90 days, 18-28°C	30	0.042 + 16.3
1 year, 13-33°C	3	0.072 + 32.5
1 year, 13-33°C	30	0.072 + 33.1

Table 701-1. Signal Conditioner Specifications (cont.)

HALF BRIDGE STRAIN

Rgage = 350 Ohms

RESOLUTION ..... 0.2 microstrain
TEMPERATURE COEFFICIENT .. ±5.2 με/°C

SYSTEM ACCURACY (EXCLUDING STABILITY OF GAGE)

CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading + microstrain)
24 hours, 21-25°C	3	0.02 + 1.5
24 hours, 21-25°C	30	0.02 + 2.1
90 days, 18-28°C	3	0.042 + 2.3
90 days, 18-28°C	30	0.042 + 2.7
1 year, 13-33°C	3	0.072 + 6.5
1 year, 13-33°C	30	0.072 + 8.8

Rgage = 120 Ohms

RESOLUTION ..... 0.5 microstrain
TEMPERATURE COEFFICIENT . ±5.5 με/°C
SYSTEM ACCURACY (EXCLUDING STABILITY OF GAGE)

CONDITIONS	A/D RATE (readings per second)	ACCURACY ±(% of reading + microstrain)
24 hours, 21-25°C	3	0.02 + 4.1
24 hours, 21-25°C	30	0.02 + 5.5
90 days, 18-28°C	3	0.042 + 6.3
90 days, 18-28°C	30	0.042 + 7.3
1 year, 13-33°C	3	0.072 + 18.3
1 year, 13-33°C	30	0.072 + 18.9

WEIGHT ..... 0.9 kg (2 lbs)

ENVIRONMENTAL ..... Meets all 2400 environmental specifications

MAXIMUM INPUT VOLTAGE LIMIT .. Refer to specification for the Four-Wire and Six-Wire Input Connectors

POWER CONSUMPTION ..... 2W max during operation

The signal conditioner is used with the 2400B High Performance A/D Converter, the 2400A-115 Four-Wire Scanner and the 2400A-116 Four-Wire Input Connector for three-wire and four-wire RTD or ohms measurement and four-wire, 350-ohm or 120-ohm, quarter-bridge strain measurement. All current ranges and modes of operation, except half-bridge strain, are selectable through the 2400B software. Strain measurements using a

half-bridge gauge are made by setting hardware switches on the signal conditioner and using the 2400A-117 Six-Wire Scanner and the 2400A-118 Six-Wire Input Connector. When used for half-bridge strain measurement, the RTD ohms signal conditioner is still available for RTD, Ohms, and 350-ohm quarter-bridge strain measurements with a four-wire scanner and a four-wire input connector. However, 120-ohm quarter-bridge strain measurements may not be selected when the half-bridge strain configuration is selected.

The 2400A-701 Signal Conditioner mounts in any of the I/O Option slots in the 2400B chassis. The Signal Conditioner resides in the same chassis as an A/D converter (2400A-109).

The signal conditioner applies current through the scanner and the input connector to a test resistance. The voltage across the test resistance is then transmitted by the input connector and scanner to the signal conditioner. This response voltage is conditioned by the signal conditioner and applied to the high and low measurement lines of the A/D Converter (2400A-109). The number returned by the 2400B CPU is in the units of measure determined by the sensor type specified in the channel definition.

Installation

The signal conditioner mounts in any I/O option slot in the 2400B as Figures 701-1 and 701-2 show. Install the signal conditioner as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connector cables from the chassis.

3. Remove the rear panel from the chassis.

Caution

Handle the signal conditioner assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. See that switch S6 on the signal conditioner is set correctly for the type of measurements to be done. (See Figure 701-3 for switch settings).

5. To select the best I/O option slot for mounting the signal conditioner, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation, of this guide.

6. Referring to Figures 701-1 and 701-2, align the signal conditioner in the selected I/O option slot so that the card edge connector is toward the front of the unit. Push the signal conditioner into the chassis mating connector.

7. Rotate the plastic tabs located at the top and bottom of the pcb until they are flush with the rear edge of the signal conditioner pcb.

8. Check to see that an A/D converter (2400A-109) is already installed in the two rightmost slots of the 2400B chassis. If not see the 2400A-109 option section for installation of the A/D converter.

9. Check to see that one four-wire scanner (2400A-115) and one four-wire input connector (2400A-116) are installed in the 2400B or 2401A chassis for every 10 channels of RTD, resistance or quarter-bridge strain measurement.

10. Check to see that one six-wire scanner (2400A-117) and one six-wire input connector (2400A-118) are installed for every five channels of half-bridge strain measurement.

11. Install the rear panel.

12. Install the connectors and cables removed in Step 2.

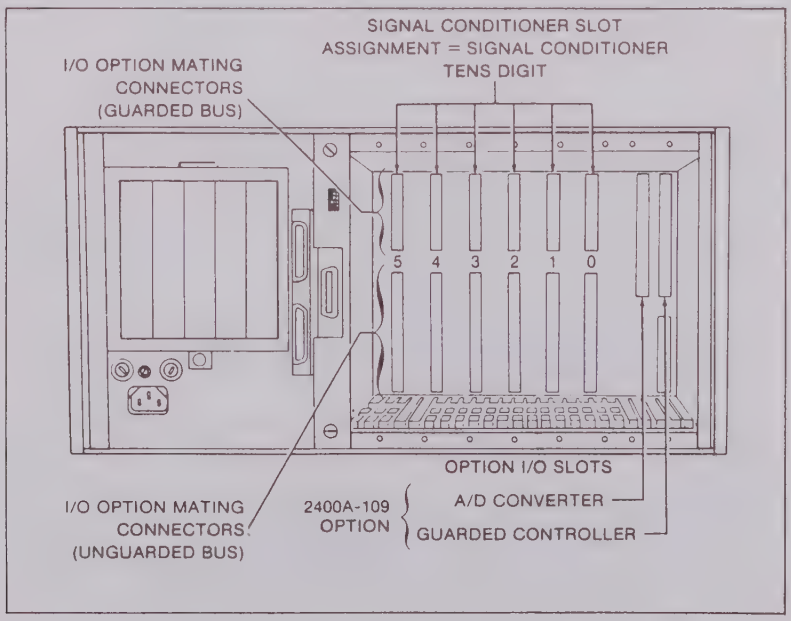

SIGNAL CONDITIONER SLOT ASSIGNMENT = SIGNAL CONDITIONER TENS DIGIT
I/O OPTION MATING CONNECTORS (GUARDED BUS)
5 4 3 2 1 0
OPTION I/O SLOTS
I/O OPTION MATING CONNECTORS (UNGUARDED BUS)
2400A-109 OPTION
A/D CONVERTER
GUARDED CONTROLLER

Figure 701-1. Signal Conditioner Locations

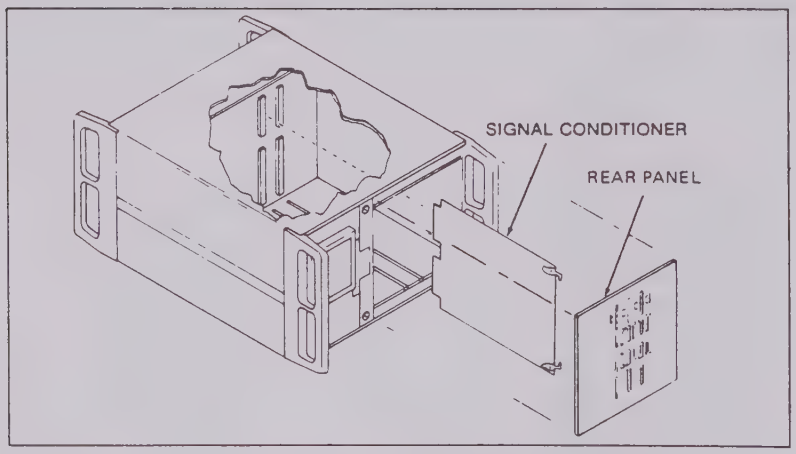


Figure 701-2. Signal Conditioner Mounting Location

Operation

Once installed in the chassis, the signal conditioner is ready for use. The user is responsible for completing external wiring connections to the input connectors from the external measurement points. Figure 701-3 shows setting for hardware switch S6 located on the signal conditioner. The switch is accessible at the rear of the 2400B chassis when the signal conditioner is installed. Be sure that S6 is set correctly for the measurements being taken.

The 120(ohms)CAL and 350(ohms)CAL settings of S6 are used to verify proper connection of the strain gauge. When the 120(ohms)CAL switch is in the active position and a strain measurement of an unstrained gauge is made, an apparent change in rgauge of about -2% or -10,000 microstrain should be observed on all channels that are defined for 120 Ohms, quarter-bridge strain measurements. The 350(ohms)CAL setting will cause the same apparent change of -10,000 microstrain on all channels defined for measurement of 350(ohms), quarter-bridge strain gauges. The above measurements are intended to be a check of proper connection of gauges. The results should not be used as a calibration point for linearizations, as inaccuracies may result.

The 2400A-701 Signal Conditioner is always used with a scanner and an input connector.

The definition for a particular channel must include the input channel number to be sampled (determined by the 2400B chassis slot holding the scanner and input connector) and the signal conditioner tens and units

digits. The signal conditioner tens digit, when used in the command SIGCND=XX, corresponds to the 2400B chassis slot holding the 2400A-701 (see Figure 701-1). The signal conditioner units digit is used by the 2400B to determine the value of current and the measurement mode for the signal conditioner. See Table 701-2 for signal conditioner units digit and corresponding measurement mode.

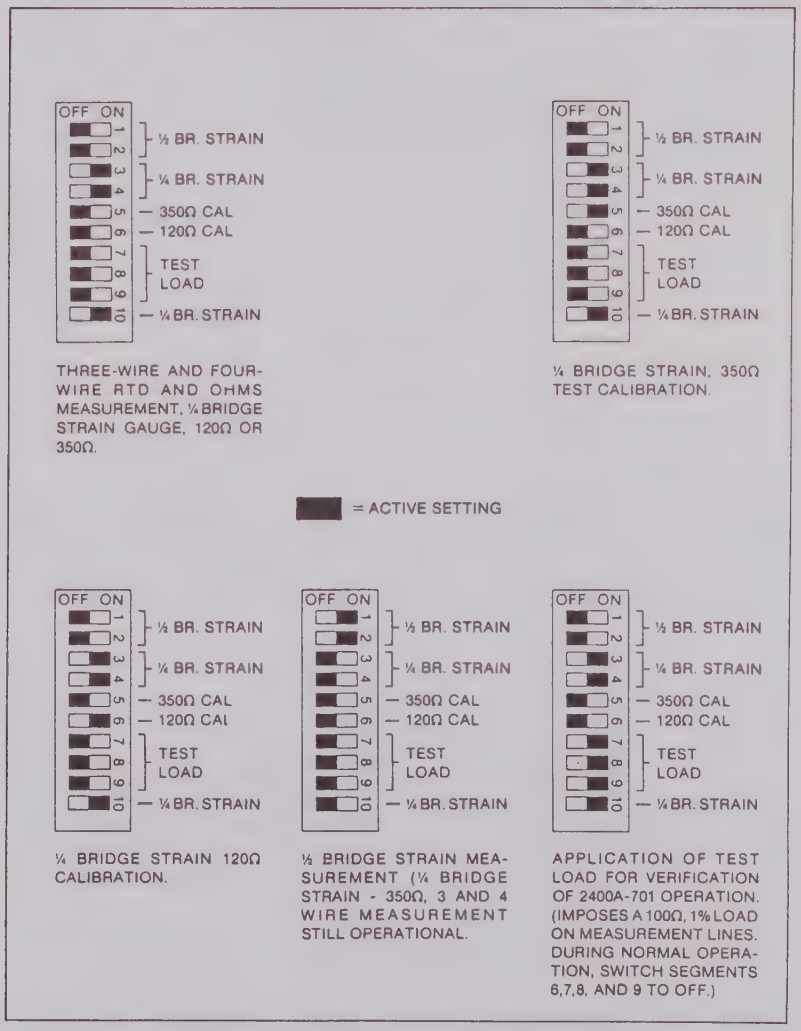

OFF ON
1 2 3 4 5 6 7 8 9 10
½ BR. STRAIN
¼ BR. STRAIN
350Ω CAL
120Ω CAL
TEST LOAD
¼ BR. STRAIN
THREE-WIRE AND FOUR-WIRE RTD AND OHMS MEASUREMENT, ¼ BRIDGE STRAIN GAUGE, 120Ω OR 350Ω.
¼ BRIDGE STRAIN, 350Ω TEST CALIBRATION.
= ACTIVE SETTING
¼ BRIDGE STRAIN 120Ω CALIBRATION.
½ BRIDGE STRAIN MEASUREMENT (¼ BRIDGE STRAIN - 350Ω, 3 AND 4 WIRE MEASUREMENT STILL OPERATIONAL.
APPLICATION OF TEST LOAD FOR VERIFICATION OF 2400A-701 OPERATION. (IMPOSES A 100Ω, 1% LOAD ON MEASUREMENT LINES. DURING NORMAL OPERATION, SWITCH SEGMENTS 6,7,8, AND 9 TO OFF.)

Figure 701-3. Switch Settings (S6)

Table 701-2. Signal Conditioner Addressing

MEASUREMENT CONFIGURATION	SIGNAL CONDITIONER UNITS DIGIT	SUGGESTED USE
0.1 mA, 3-Wire 0.1 mA, 4-Wire	SIGCND = X8* SIGCND = X0	Resistance 0 to 4 kΩ, Resistance 4k to 64kΩ, 30 rdgs./sec.
1 mA, 3-Wire 1 mA, 4-Wire	SIGCND = X1 SIGCND = X2	Resistance 0 to 4kΩ, Resistance 4k to 8kΩ, 30 rdgs./sec., 100Ω RTD
10 mA, 3-Wire 10 mA, 4-Wire ¼ Bridge, 350Ω Strain Measurement	SIGCND = X3 SIGCND = X4 SIGCND = X0† BRCONF = 12**	Resistance 0 to 100Ω, 10Ω RTD 350Ω, ¼ Bridge Strain Measurement; Current Sources = 10 mA
¼ Bridge, 120Ω*** Strain Measurement	SIGCND = X0 BRCONF = 11	120Ω, ¼ Bridge Strain Measurement; Current Sources = 10 mA
½ Bridge; 350Ω, 120Ω*** Strain Measurement	SIGCND = X0 BRCONF = 10	350Ω or 120Ω, ½ Bridge Strain Measurement; Current Sources = 10 mA

Example Definitions

Example definitions for various measurements using the 2400A-701 are provided in the following paragraphs to aid the user in system configuration. Refer also to the Programming Guide. Table 701-3 lists the equipment used in the example system for the example definitions.

100-OHM RTD MEASUREMENT (1 MA, FOUR-WIRE)

Channel definitions for four-wire scanner channels 0, 1, 2:

```
DEFN AICHAN = 0 TO 2, SENSOR = RTD, SIGCND = 22;!
```

This definition assumes the default values of RTD parameters listed under the heading RTD Sensor Specifications in the 2400B Programming Guide.

RESISTANCE MEASUREMENT

The following provides channel definitions for four-wire scanner channels 3 and 4, using the 100 uA current source, four-wire measurement:

```
DEFN AICHAN = 3 TO 4, SENSOR = OHMS, SIGCND = 20;!
```

The following provides channel definitions for four-wire scanner channels 5 and 6, using 10 mA current source, three-wire measurement:

```
DEFN AICHAN = 5 TO 6, SENSOR = OHMS, SIGCND = 23;!
```

QUARTER-BRIDGE STRAIN MEASUREMENT (R GAUGE = 350 OHMS, GAUGE FACTOR = 2)

The following provides channel definitions for four-wire scanner channels 7, 8, and 9:

```
DEFN
AICHAN = 7 TO 9, SENSOR = STRAIN,
BRCONF = 12, EXCUR = .01, SIGCND = 20;
!
```

All strain measurements using the 2400A-701 are made using the 0.1V A/D range.

HALF-BRIDGE STRAIN MEASUREMENT (R GAUGE = 350 OR 120 OHMS)

Set hardware switch S6 as in Figure 701-3 for half-bridge strain measurement. The following provides channel definitions for six-wire scanner channels 10 through 18;

```
DEFN
AICHAN = 10 TO 18, SENSOR = STRAIN,
BRCONF = 10, EXCUR = .01, SIGCND = 20;
!
```

The CSINIT command (see Programming Guide) should be used to initialize all quarter-and-half-bridge strain channels.

Table 701-3. Example System Equipment

Model Number	Equipment Name	2400B I/O Slot
2400A-109	A/D Converter	-
2400A-115	Four-Wire Scanner	0
2400A-116	Four-Wire Input Connector	0
2400A-117	Six-Wire Scanner	1
2400A-118	Six-Wire Input Connector	1
2400A-701	Signal Conditioner (S6 set as in Figure 701-3 for 1/2 bridge strain measurement)	2

Installation Verification Test

To verify proper installation of the signal conditioner, set switch S6 as Figure 701-3 shows for Application of Test Load for Verification of 2400A-701. Use the following test to verify correct installation and operation of the signal conditioner:

1. Apply power to the 2400B by depressing the front panel POWER switch.

2. Send the following definition through the host device to the 2400B (where x equals the slot number where 2400A-701 resides):

```
DEFN
AICHAN = 0, SENSOR = OHMS, MAX = .1, SIGCND = X0;
AICHAN = 1, SENSOR = OHMS, SIGCND = X1;
AICHAN = 2, SENSOR = OHMS, SIGCND = X2;
AICHAN = 3, SENSOR = OHMS, MAX = 6.4, SIGCND = X3;
AICHAN = 4, SENSOR = OHMS, MAX = 6.4, SIGCND = X4;
AICHAN = 5, SENSOR = OHMS, MAX = 6.4, SIGCND = X5;
AICHAN = 6, SENSOR = OHMS, SIGCND = X6;
AICHAN = 8, SENSOR = OHMS, MAX = .1, SIGCND = X8;
!
```

Note

If a scanner or signal conditioner resides in slot 0 of the 2400B, change the numbers following the AICHAN command to address an empty slot, or temporarily disconnect the board in slot 0 by removing it. (Power must be off when removing a board from the mainframe.)

3. Send the commands listed in Table 701-4 to the 2400B and verify that the corresponding value is returned.

Service Information

Troubleshooting procedures, parts lists, schematics and theory of operation are given in the 2400B Service Manual.

Table 701-4. Verification Test Commands

COMMAND	RETURNED VALUE
SEND AI(0)!	100Ω ±2Ω
SEND AI (1)!	100Ω ±2Ω
SEND AI (2)!	100Ω ±2Ω
SEND AI (3)!	100Ω ±2Ω
SEND AI (4)!	100Ω ±2Ω
SEND AI (5)!	-250Ω ±2.5Ω
SEND AI (6)!	-20Ω ±1Ω
SEND AI (8)!	100Ω ±2Ω

OPTION 2400A-702 FULL/HALF-BRIDGE STRAIN SIGNAL CONDITIONER

Description

The 2400A-702 Full/Half-Bridge Strain Signal Conditioner extends the measurement capabilities of the 2400A-109 High Performance A/D Converter to include half and full Wheatstone bridge strain gauge and transducer measurement. This signal conditioner transmits a precise excitation voltage to either a half or full-bridge through a 2400A-117 Six-Wire Scanner and a 2400A-118 Six-Wire Input Connector.

The signal conditioner supplies one of seven software selectable excitation voltages (4V, 5V, 8V, 10V, 12V, 15V, or 20V) to the bridge during measurement. A single precision half-bridge completion network on the signal conditioner is software selected to complete the full-bridge, and half-bridge strain measurements. Standard initialization and linearization functions in the 2400B eliminate the need for external balance potentiometers and charts or graphs to compensate for strain gauge nonlinearity. Five bridges may be connected to a single scanner and 99 scanners may be installed in a 2400B system, allowing a total of 495 bridges per system. Only one signal conditioner is needed per system to obtain any configuration desired. The signal conditioner may be installed in any of the I/O option slots in the 2400B chassis. This signal conditioner must be installed in the same chassis as the 2400A-109 High Performance A/D Converter used in the system. Refer to Tables 702-1 and 702-2 for signal conditioner specifications.

Table 702-1. Specifications, Full-Bridge Configuration

NOTE

All specifications pertain to a system consisting of a 2400A-109 High Performance A/D Converter, a 2400A-702 ½, Full Bridge Signal Conditioner, a 2400A-117 Six-Wire Scanner(s), and a 2400A-118 Six-Wire Input Connector(s).

RESOLUTION ..... 1.0 uV (100 mV range of A/D converter)

NOTE

An error message appears if the input voltage to the A/D converter is greater than 100 mV. To maintain high resolution, reduce the excitation voltage (EXVOLT).

MAXIMUM ERROR DUE TO LEAD RESISTANCE ..... $2(RI)^2/(Rg \times 10^4)\%$; where RI is the average resistance of the excitation interconnection wires and Rg is the effective resistance of the bridge between the +EXC wires and the -EXC wires. For example, if RI = 50 ohms and Rg = 700 ohms (½ bridge), the percentage of error would be $\frac{2(50)^2}{700(10)^4} = 0.0007\%$.

TEMPERATURE COEFFICIENT ..... $\pm$(0.002% of input $\mu\epsilon$ + 0.2 μV/°C)

Table 702-1. Specifications, Full-Bridge Configuration (cont.)

ACCURACY

A/D RATE (readings per second)	ACCURACY ±(% of input in microstrain + microvolts*)		
	24 HOURS (23°C)	90 DAYS (18°C-28°C)	1 YEAR (13°C-33°C)
3	0.004% + 8μV	0.015% + 9μV	0.03% + 12μV
30	0.004% + 12μV	0.015% + 13μV	0.03% + 16μV

*To adjust the above accuracy specification for specific bridge configurations and excitation voltages, convert the microvolts to microstrain using the multiplication factors listed in the table below. For example, in a bridge configuration number 3, with an excitation voltage of 8V, multiply the number of microvolts by a factor of 0.25 since there are 0.25 microstrain per microvolt.

BRIDGE CONFIURATION NUMBER (BRCONF)	SELECTED EXCITATION VOLTAGE (EXVOLT)						
	4V	5V	8V	10V	12V	15V	20V
0, 3 1, 4	0.50	0.40	0.25	0.20	0.17	0.13	0.10
2, 5, 6 7, 8	0.25	0.20	0.13	0.10	0.09	0.07	0.05
9	0.13	0.10	0.06	0.05	0.04	0.03	0 03

The table above does not consider sensor and setup errors. Gage factor (K) is 2.00 for all the multiplication factors. Other values of K can be used by multiplying these factors by K/2.

CURRENT LIMITER ..... Operates when $\frac{\text{excitation voltage}}{\text{gage resistance}} > 0.09$ Ampere (invalid readings result when current limiter operates)

Table 702-2. Specifications, Half-Bridge Configuration

NOTE

All specifications pertain to a system consisting of a 2400A-109 High Performance A/D Converter, a 2400A-702 ½, Full Bridge Signal Conditioner, a 2400A-117 Six-Wire Scanner(s), and a 2400A-118 Six-Wire Input Connector(s).

RESOLUTION ..... 1.0 uV (100 mV range of A/D converter)

NOTE

An error message appears if the input voltage to the A/D converter is greater than 100 mV. To maintain high resolution, reduce the excitation voltage (EXVOLT).

Table 702-2. Specifications, Half-Bridge Configuration (cont.)

ACCURACY

A/D RATE (readings/ second)	ACCURACY ±(% of input + microvolts*)		
	24 HOURS (23°C)	90 DAYS (18°C-28°C)	1 YEAR (13°C-33°C)
3	0.004% + 10μV	0.021% + 11μV	0.043% + 14μV
30	0.004% + 14μV	0.021% + 15μV	0.043% + 18μV

If the software initialization is not used, add (EXVOLT + 1) 250 microvolts to the above specifications.

NOTE

Initialization refers to the Strain Measurement Init statement described in Section 5 of this manual.

*To adjust the above accuracy specification for specific bridge configurations and excitation voltages, convert the microvolts to microstrain using the multiplication factors listed in the table below. For example, in a bridge configuration number 3, with an excitation voltage of 8V, multiply the number of microvolts by a factor of 0.25 since there are 0.25 microstrain per microvolt.

BRIDGE CONFIGURATION NUMBER (BRCONF)	SELECTED EXCITATION VOLTAGE (EXVOLT)						
	4V	5V	8V	10V	12V	15V	20V
0, 3 1, 4	0.50	0.40	0.25	0.20	0.17	0.13	0.10
2, 5, 6 7, 8	0.25	0.20	0.13	0.10	0.09	0.07	0.05
9	0.13	0.10	0.06	0.05	0.04	0.03	0.03

The table above does not consider sensor and setup errors. Gage factor (K) is 2.00 for all the multiplication factors. Other values of K can be used by multiplying these factors by K/2.

MAXIMUM ERROR DUE TO LEAD RESISTANCE .. $2(RI)^2/(Rg \times 10^4)\%$; where RI is the average resistance of the excitation interconnection wires and Rg is the effective resistance of the bridge between the +EXC wires and the -EXC wires. For example, if RI = 50 ohms and Rg = 700 ohms (½ bridge), the percentage of error would be $\frac{2(50)^2}{700(10)^4} = 0.0007\%$.

TEMPERATURE COEFFICIENT ..... ±(0.002% of input με + 0.2 μV/°C)

Table 702-2. Specifications, Half-Bridge Configuration (cont.)

CURRENT LIMITER	Operates when $\frac{\text{excitation voltage}}{\text{gage resistance}} > 0.09$ Ampere (invalid readings result when current limiter operates)
WEIGHT	0.9 kg (2 lbs)
ENVIRONMENTAL	Meets all 2400 environmental specifications
POWER CONSUMPTION	2W maximum during operation

Installation

The signal conditioner mounts in any I/O option slot in the 2400B chassis as Figures 702-1 and 702-2 show. Install the signal conditioner as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connector cables from the chassis.

3. Remove the rear panel from the chassis.

Caution

Handle the signal conditioner pcb by its edges to avoid contaminating it with oil from the hands. The use of gloves is recommended.

4. Check to be sure that all individual switches on switch block S4 at the back edge (opposite the edge with the protruding gold connector fingers) of the signal conditioner are in the off position. If the switches are not in the off position, software addressing of the excitation voltages may be disabled and errors may be introduced by the resistance of the hook-up wire.

5. To select the best I/O option slot for mounting the signal conditioner, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

6. Slide the pcb into the guides on the chosen slot with the protruding connector-edge in first. Push the signal conditioner in until it mates with the female connector on the chassis motherboard.

7. Rotate the small plastic handles at the top and bottom of the pcb until they are flush with the rear edge.

8. Check to make sure that a 2400A-109 High Performance A/D Converter is already installed in the two rightmost slots of the 2400B chassis.

9. Check to see that one 2400A-117 Six-Wire Scanner and one 2400A-118 Six-Wire Input Connector are installed in a 2400B or 2401A chassis for every five bridges to be used in the system.

10. Reinstall the rear panel.

11. Reinstall the connectors and cables removed in Step 2.

Operation

Once installed in the chassis, the signal conditioner is ready for use. The user is responsible for completing external wiring connections from the configured strain gauge bridges or transducers to the Six-Wire Input Connectors.

The signal conditioner is always used with a scanner and an input connector. Consequently, the software definition for a particular scanner channel must include the location number of the input channel to be sampled, the signal conditioner slot location, and the desired setup configuration details. The units digit of the scanner channel definition (must be even, 0, 2, 4, 6 or 8) corresponds to the channel on a particular scanner; the tens and hundreds digits correspond to the slot in either the 2400B or 2401A chassis holding the scanner. The units and hundreds digits of the signal conditioner definition are ignored. The tens digit of the signal conditioner definition corresponds to the slot in which the signal conditioner is installed.

Note that a strain or transducer measurement can also be taken with a system of either 2400A-101 Three-Wire High Performance Scanners/2400A-108 Voltage Input Connectors or 2400A-117 Six-Wire Scanners/2400A-118 Six-Wire Input Connectors or combinations of these. The 2400A-702 cannot be used on channels using Three Wire High Performance Scanners and Voltage Input Connectors. Instead, external voltage excitation sources must be used. However, accuracy of measurement is directly related to the accuracy of the excitation source(s) used. Half-bridge completion network(s), if needed, would have to be supplied by the user also. Most of the conveniences provided by the 2400B strain software could still be used, except for software controlled selection of excitation voltage value and connection of half-bridge completion network, since these require use of a 2400A-702. Proper software definitions for strain measurements without the 2400A-702 option are described in the 2400B Programming Guide.

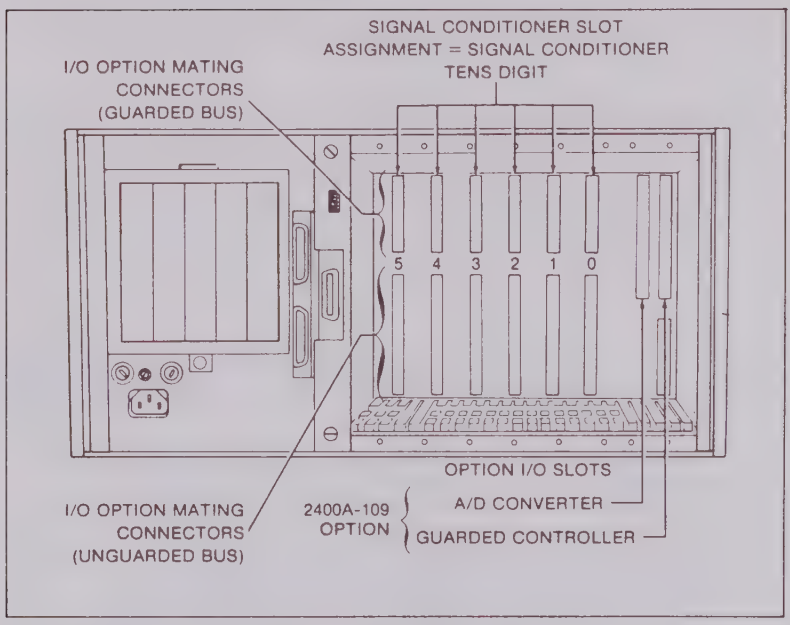


Figure 702-1. Signal Conditioner Location

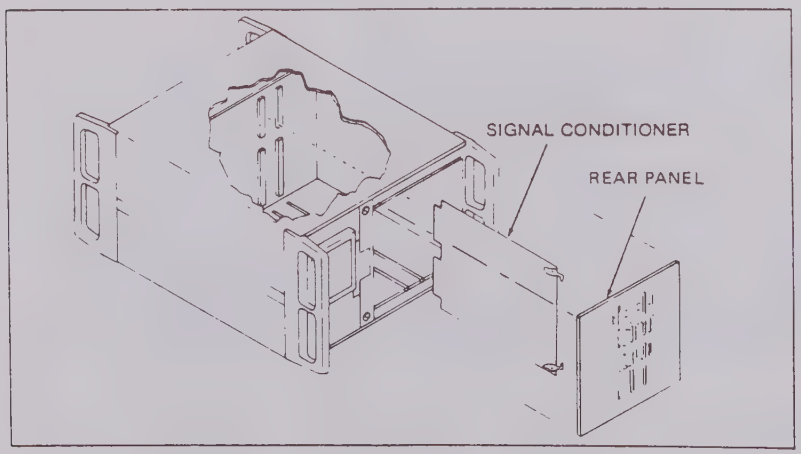


Figure 702-2. Signal Conditioner Mounting Location

Software totally compensates for the nonlinearities of the Wheatstone bridge configuration being used. As a result, the value of microstrain returned to the user by the 2400B system is correct; the need for data reduction in the form of manual calculations and lookup tables or graphs is eliminated. The software contains equations for nine general configurations, to cover all typical setups. It is important that the configuration being used is connected to the proper terminals of the 2400A-118 Six-Wire Input Connector or errors will be introduced. Example definitions for various strain measurement configurations using the 2400A-702 are provided below to aid the use of the software definitions. Detailed software explanation is given in the 2400B Programming Guide. An example of a transducer measurement definition is also provided in the Programming Guide.

FULL-BRIDGE, EXAMPLE DEFINITION

The following example applies to a full-bridge of strain gauges, one gauge principally active and the others used for temperature compensation (bridge configuration 3). In the example, the signal conditioner is in slot 0, the scanner in slot 3 of the same chassis, excitation voltage is 4 volts, the gauge factor is 2.05, the gauge resistance is 350 ohms, and a maximum strain specification for the gauge is 2%. In addition, two of these identical gauge bridge setups are connected to the first two input channels (0 and 2) on the scanner.

```
DEFN
AICHAN=30 TO 32, SENSOR=STRAIN, EXVOLT=4, BRCONF=3,
SIGCND=00, GAGEFC=2.05, RNOM=350, GAGLIM=2;
!
```

HALF-BRIDGE, EXAMPLE DEFINITION

The following example applies to a half-bridge of strain gauges, one aligned with the maximum principal strain vector and the other aligned perpendicular to the first (Poisson active bridge configuration 1). In the example, the signal conditioner is in slot 0, scanner is in slot 3 of the same chassis, the excitation voltage is 5 volts, the gauge factor is 2.00, and the gauge resistance is 120 ohms. In addition, the maximum strain specification is not known, and three of these setups are connected to the last three channels of the scanner:

```
DEFN
AICHAN=34 TO 38, SENSOR=STRAIN, SIGCND=00,
BRCONF=1, EXVOLT=5, RNOM=120;
!
```

Note

Refer to the 2400B Programming Guide for detailed explanation of definition parameters.

Installation Verification Test

To verify proper installation of the signal conditioner, install a Six-Wire Scanner (2400A-117) and a Six-Wire Input Connector (2400A-118) in any slot in the 2400B or 2401A chassis. Use the following test to check for correct installation and operation:

1. Disconnect any existing wiring from channel 0 of the 2400A-118 Six-Wire Input Connector.

2. Wire together terminals W, X, and T (identified on the input connector decal). Also wire together terminals S, U, and Y. This attaches the excitation voltage output of the signal conditioner to the input of the A/D converter. Connect a 1000-ohm resistor across the two nodes (for example, between terminal posts S and T). This simulates a full-bridge load and causes a current flow; the exact resistance value is not critical.

3. Install the connector as previously described.

4. Apply power to the 2400B by depressing the front panel POWER switch.

5. Send the following definition through the host computer to the 2400B:

```
DEFN
AICHAN = xy0, SENSOR = VOLT, SIGCND = vw;
!
```

Where:
xy = system slot location of the scanner
v = 2400B slot location of the signal conditioner
w = data code for signal conditioner excitation voltage as listed in Table 702-3.

Table 702-3. Excitation Voltage Codes

CODE (w)	EXCITATION VOLTAGE VALUE	CORRECT RETURNED VALUE
0	4V	4.0000 ±.0014 V
1	5V	5.0000 ±0.0016V
2	8V	8.0000 ±0.0084V
3	10V	10.0000 ±0.0090V
4	12V	12.0000 ±0.0096V
5	15V	15.0000 ±0.0105V
6	20V	20.0000 ±0.0120V

6. Measure the output of the signal conditioner by sending the following command to the 2400B from the host computer:

```
SEND AI(xy0)!
```

7. Verify that the value returned is correct according to Table 702-3.

8. Repeat Steps 4 and 5 for at least two of the values for w corresponding to two excitation voltages as described in Table 702-3.

9. This completes the installation verification test. Turn power off, and reconnect any wiring previously removed for the test.

System Installation Verification

After the complete system (Signal Conditioner, Six-Wire Scanners and Six-Wire Input Connectors) have been installed in the chassis, and the bridges have been connected, verify system operation as follows:

1. Apply power to the 2400B by depressing the front panel POWER switch.

2. Send the following definition to the 2400B through the host device:

```
DEFN
AICHAN=xyz, SENSOR=STRAIN,
SIGCND=v0, BRCONF=a, EXVOLT=4;
!
```

Where:
xyz = the scanner channel number in the system
v = the slot number of the signal conditioner
a = 0 for half-bridge connection; 3 for full-bridge connection

3. Initialize the system to remove any offset outputs (which may prestrain the gauge during installation), gauge tolerances, or other offset error sources, by sending the following bus command to the 2400B through the host computer:

```
CSINIT (xyz)!
```

4. Temporarily attach a test resistor across the terminals of the strain gauge (or arm of the transducer bridge) on the test specimen connected between terminals T and U or Y on one channel of an input connector. The effect of the test resistor is to create an equivalent strain (or engineering unit output for transducer measurement) input. The one percent tolerance resistor value to give close to a 2% change in resistance for different standard bridge arm resistances is given in Table 702-4. This resistor value will give the equivalent of 1% strain or 10,000 microstrain for the assumed gauge factor of 2 used in the definition.

5. Measure the equivalent strain (or other engineering unit being simulated) by sending the following command to the 2400B from the host computer:

```
SEND AI(xyz)!
```

6. The returned value should be within the specifications listed in Table 702-4. If it is not, then the wiring is incorrect or the system is has a malfunctioning part.

Table 702-4. Test Resistor/Microstrain Values

R GAGE	R TEST (1%)	MICROSTRAIN	R TEST (5%)	MICROSTRAIN
120 ohms	5.9 kohms	-9967	5.6 kΩ	-10490
350 ohms	16.9 kohms	-10145	18 kΩ	-9537
600 ohms	29.4 kohms	-10000	30 kΩ	-9804
1000 ohms	48.7 kohms	-10060	47 kΩ	-10417
Any other value resistor should yield, in microstrain: $\frac{(\text{R gage})\ (10^6)}{2(\text{R gage} + \text{R test})}$				

7. Repeat Steps 2 through 6 for additional channels desired to be checked.

8. This completes the system installation verification.

Note

The accuracy of the returned microstrain value depends on the resistor tolerance used and the system accuracy, and can be computed from the following formula:

$$\text{Tolerable error} = \pm \left(\frac{(\text{R test})(\%\ \text{tolerance of R test})(\text{correct returned microstrain value})}{(100)(\text{R gage}) + (\text{R test})(100 + \%\ \text{tolerance of R test})} + 8.6/8.1\ [\text{half/full bridge BRCONF=0/3}] \right) \text{microstrain}$$

An error message appears if the input voltage to the A/D converter is greater than 100 mV. To maintain high resolution (10 uV), reduce the excitation voltage (EXVOLT).

Service Information

Troubleshooting procedures, parts lists, schematics, and theory of operation are given in the 2400B Service Manual.

SECTION 8

DIGITAL INPUT OPTIONS

CONTENTS, SECTION 7 ANALOG INPUT OPTIONS

Option 2400A-101 High Performance Scanner 101-1
Option 2400A-102 Thermocouple Input Connector 102-1
Option 2400A-106 Current Input Connector 106-1
Option 2400A-108 Voltage Input Connector 108-1
Option 2400A-109 High Performance A/D Converter 109-1
Option 2400A-115 Four-Wire Scanner 115-1
Option 2400A-116 Four-Wire Input Connector 116-1
Option 2400A-117 Six-Wire Scanner 117-1
Option 2400A-118 Six-Wire Input Connector 118-1
Option 2400A-119 AC Volts Input Connector 119-1
Option 2400A-701 RTD/Ohms/Quarter-Half Bridge Conditioner 701-1
Option 2400A-702 Full/Half-Bridge Strain Signal Conditioner ... 702-1

CONTENTS, SECTION 8 DIGITAL INPUT OPTIONS

Option 2400A-103 Digital Input 103-1
Option 2400A-104 Status Input 104-1
Option 2400A-110 Screw Terminal Connector 110-1
Option 2400A-111 Solder Pin Connector 111-1
Option 2400A-113 Counter/Totalizer 113-1
Option 2400A-114 Interrupt Input 114-1

CONTENTS, SECTION 9 OUTPUT OPTIONS

Option 2400A-110 Screw Terminal Connector 110-1
Option 2400A-111 Solder Pin Connector 111-1
Option 2400A-301 Status Output 301-1
Option 2400A-302 Current/Voltage Analog Output 302-1
Option 2400A-305 Resistance Output (1 Ohm to 4 Kilohms) 305-1
Option 2400A-306 Resistance Output (25 Ohms to 100 Kilohms) ... 306-1
Option 2400A-307 Stepper Motor Controller 307-1

OPTION 2400A-103 DIGITAL INPUT

Description

The Digital Input assembly (Option 2400A-103) is a plug-in assembly that allows the 2400B Intelligent Computer Front End to accept 32-bit parallel digital data from an external source. Input data can be in two formats: 7-digit BCD (Binary Coded Decimal) or 24-bit binary, as shown in Figure 103-1. Table 103-1 gives Digital Input Assembly specifications, and an equivalent circuit for an input on the Digital Input assembly is given in Figure 103-2.

The Digital Input option is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. By using 2402A I/O Extender Chassis, up to 32 assemblies (32 inputs) may be installed per system.

Input data is applied through a 50-pin, subminiature, D-type connector that mates with the Screw-Terminal Connector (Option 2400A-110), or the Solder-Pin Connector (Option 2400A-111). The Screw-Terminal or Solder-Pin Connector permits easy electrical connection to the external data source.

Data transfer is controlled by one of three handshake sequences. Refer to the following Operation paragraphs for a detailed description of the handshake sequences and data formats.

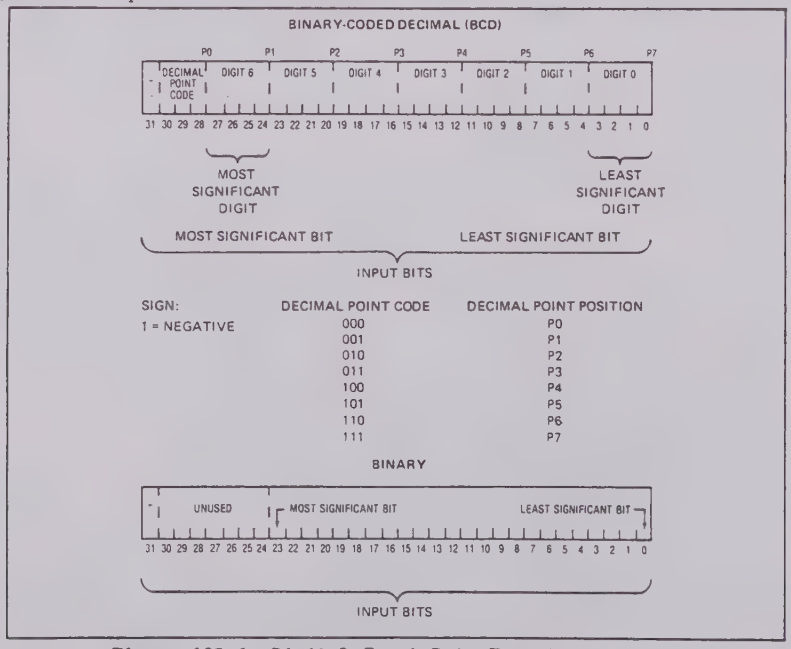


Figure 103-1. Digital Input Data Formats

Table 103-1. Digital Input Specifications

Number of Inputs Per Assembly	One, non-isolated.
Number of Digits Per Input	7 BCD digits or 24 binary digits.
Maximum Number of Inputs Per System	32 (32 assemblies per system)
Logic Levels	Pulled-up low power Schottky TTL inputs with static protection (see Figure 103-2). Vin <0.75V for input Low. 2.5 < Vin < 8V for input High.
Control Inputs	Three 2-wire handshake methods. Handshake signals may be inverted and may be inhibited until data is sampled by the 2400
Power Consumption	7 watts per pcb added to the system.
Weight	0.4 kg. (1 lb.)
Environmental	Meets all the environmental specifications of the 2400

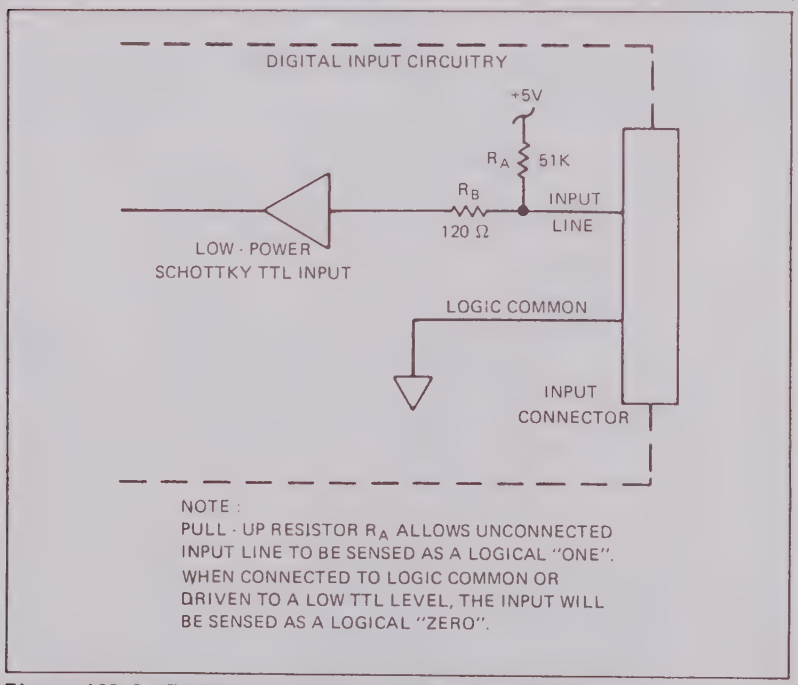

DIGITAL INPUT CIRCUITRY
+5V
R_A 51K
R_B
120 Ω
INPUT LINE
LOW - POWER SCHOTTKY TTL INPUT
LOGIC COMMON
INPUT CONNECTOR
NOTE :
PULL - UP RESISTOR R_A ALLOWS UNCONNECTED INPUT LINE TO BE SENSED AS A LOGICAL "ONE". WHEN CONNECTED TO LOGIC COMMON OR DRIVEN TO A LOW TTL LEVEL, THE INPUT WILL BE SENSED AS A LOGICAL "ZERO".

Figure 103-2. Equivalent Circuit for One Digital Input, Including Control, Data, and Handshake Inputs

Installation

The Digital Input pcb mounts in any of the I/O option slots in the 2400B or 2402A a Figure 103-3 shows. Install the pcb as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Remove the rear panel from the chassis.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. Locate the Card Select Switches on each pcb (see Figure 103-4) and assign consecutive card numbers (starting with 0) to each pcb by setting the switches to the patterns shown in Table 103-2. The number selected determines the input channel assigned to each pcb. Example: Card 0 provides input 0, Card 1 provides input 1, and so on.

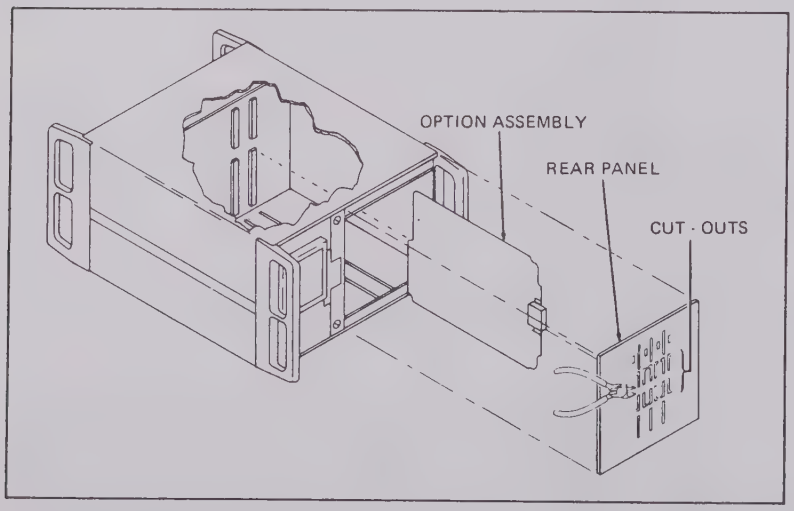


Figure 103-3. I/O Option Mounting Locations

5. To select the best I/O option slot for mounting the Digital Input assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

6. Align the pcb in the selected I/O option slot so that its card-edge connector is toward the front of the chassis, and the subminiature, type-D connector is toward the back of the unit. Push the pcb into the chassis mating connector.

7. Replace the rear panel, removing 2400B rear panel connector cutouts as necessary. Attach the option identification decal to the rear panel as shown in Figure 103-5.

Operation

Once installed in the chassis, the Digital Input assembly is ready for use and requires no operator attention. However, steps need to be taken to properly interface the assembly with digital input data. These steps are covered in the following paragraphs. You will also need to complete the cable and pin connections to the remote data source. Use either the Screw Terminal Connector (Option 2400A-110) or the Solder Pin Connector for this purpose. The pin assignments for the Digital Input assembly are given in Table 103-3.

DATA INPUT HANDSHAKE PROCESS

Three handshake methods exist for loading data into the Digital Input assembly. Each method is independent of the others, but has the same effect. To select the method you wish to use, simply connect the external device to the proper handshake pins on the input connector. For the following discussions, refer to Table 103-3 for pin connections and Figure 103-5 for timing diagrams of the handshake sequences.

Single input mode or continuous input mode is selected by the connection of connector Pin 20. In single input mode, data may be loaded only once between samplings by the 2400B. Once a load has occurred, the handshake process is inhibited until the 2400B has retrieved the input data from the Digital Input assembly. The Digital Input assembly is placed in a single input mode by connecting pin 20 to Logic Common.

In continuous input mode, the handshake and data loading process may be repeated between sampling of the input data by the 2400B. Only the latest data loaded is be detected during the sampling. The Digital Input assembly is placed in continuous input mode by leaving pin 20 unconnected.

The Digital Input assembly can be configured to continuously update data from a device that cannot answer a handshake signal, such as a BCD thumbwheel switch. To do this, the Digital Input assembly is configured with a jumper to provide its own response to its handshake signal. To allow the Digital Input assembly to continuously update in this way, install a jumper between pins 12 (LOAD2) and 14 (ACK2) on the input connector.

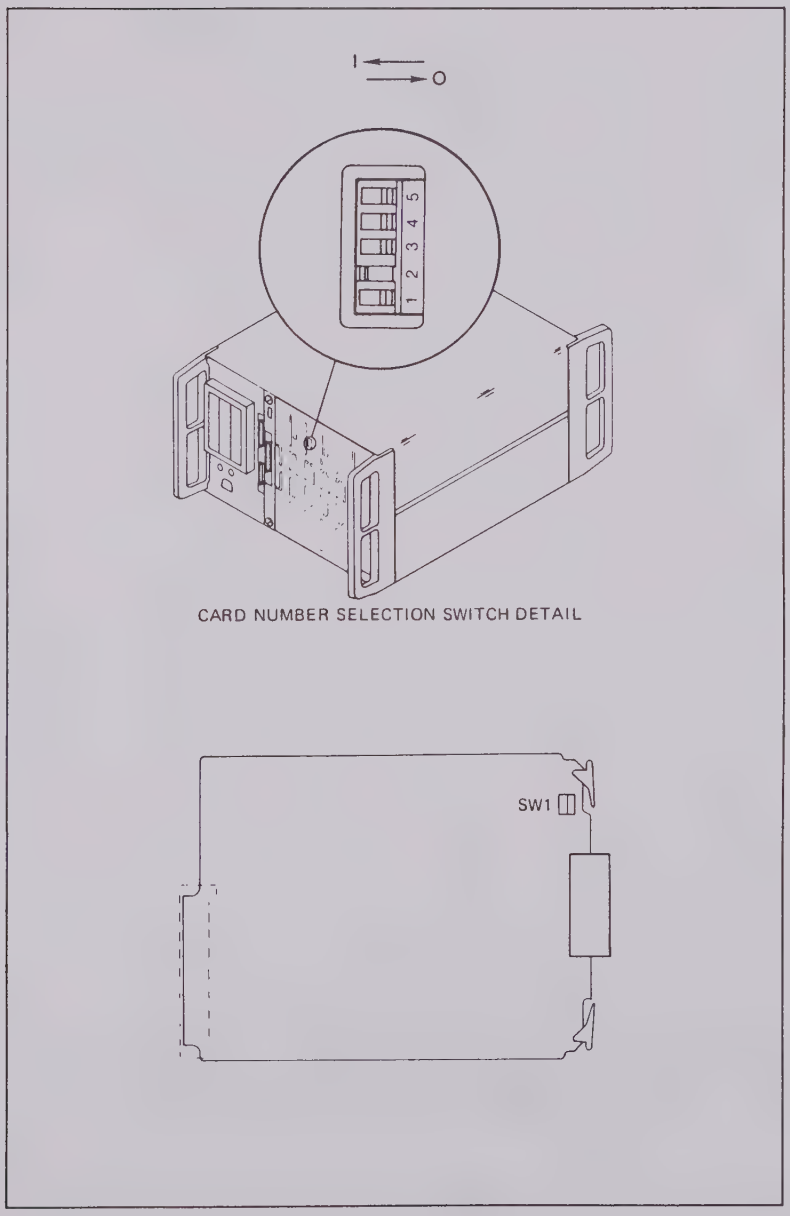


Figure 103-4. Card Select Switch Location

Table 103-2. Digital Input Card Selection Switch Settings

LEFT = ONE, RIGHT = ZERO S1 SWITCH SETTING = X X X X X						
Card Number	Switch Segments					Digital Input Channel No.
	B5	B4	B3	B2	B1	
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	0	0	1	0	2
3	0	0	0	1	1	3
4	0	0	1	0	0	4
5	0	0	1	0	1	5
6	0	0	1	1	0	6
7	0	0	1	1	1	7
8	0	1	0	0	0	8
9	0	1	0	0	1	9
10	0	1	0	1	0	10
11	0	1	0	1	1	11
12	0	1	1	0	0	12
13	0	1	1	0	1	13
14	0	1	1	1	0	14
15	0	1	1	1	1	15
16	1	0	0	0	0	16
17	1	0	0	0	1	17
18	1	0	0	1	0	18
19	1	0	0	1	1	19
20	1	0	1	0	0	20
21	1	0	1	0	1	21
22	1	0	1	1	0	22
23	1	0	1	1	1	23
24	1	1	0	0	0	24
25	1	1	0	0	1	25
26	1	1	0	1	0	26
27	1	1	0	1	1	27
28	1	1	1	0	0	28
29	1	1	1	0	1	29
30	1	1	1	1	0	30
31	1	1	1	1	1	31

Throughout the following discussion control signals are considered active in the HIGH logic state. However, the polarity of each signal may be inverted by connecting the proper pin on the input connector to Logic Common (as listed in Table 103-3). For example, if the "Invert LOAD 1" signal is used, all references to LOAD 1 will be the reversed.

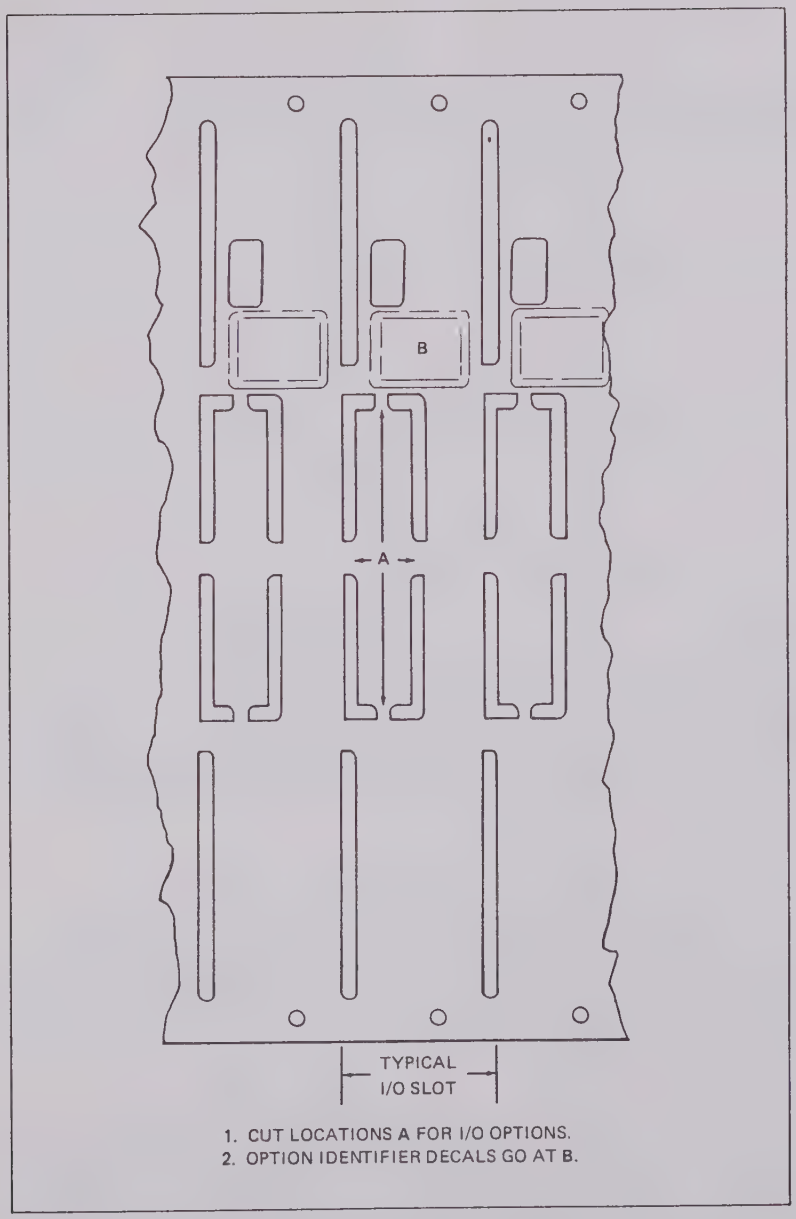


Figure 103-5. Rear Panel Detail

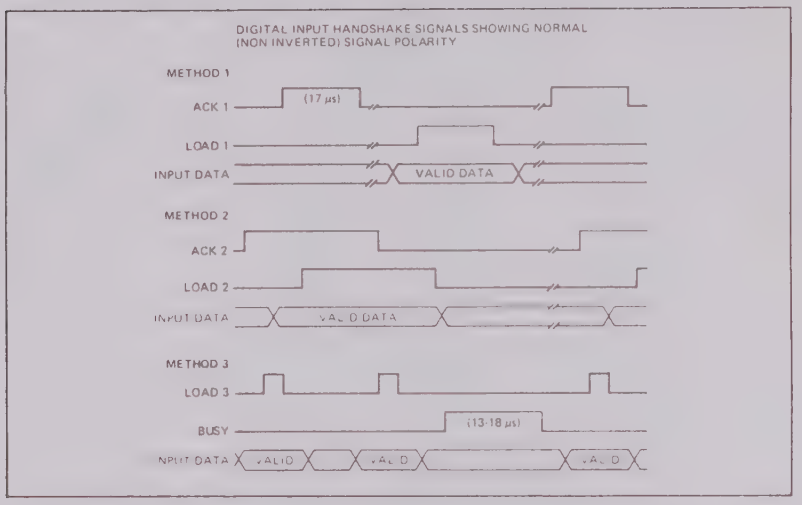


Figure 103-6. Handshake Sequence Timing Diagram

Handshake Method 1

Immediately following power-up, ACK1 (acknowledge) is set high briefly. ACK1 is a 17-microsecond pulse generated by the Digital Input assembly when it is ready to load data. Data is entered by the external device with the LOAD1 control signal. In the continuous mode, ACK1 is set high again after LOAD1 is reset. In the single mode, ACK1 is inhibited until the input data is sampled by the 2400B.

Handshake Method 2

Following power-up, ACK2 is set high by the Digital Input assembly. LOAD2 may then be set high by the external device to load the input data. ACK2 will be returned to the low state once the data is received. Then LOAD2 may be set low. In the continuous mode, ACK2 will again go high after LOAD2 goes low. In the single mode ACK2 will remain inactive until the 2400B has sampled the data. In either case, LOAD2 must be reset before the cycle may be repeated.

Handshake Method 3

LOAD3 may be set high by the external device at any time. In the continuous mode, each assertion of LOAD3 will cause the input data to be loaded. In the single mode, only the first LOAD3 following power-up or following a data sampling by the 2400B, will be effective. The Digital Input assembly generates a BUSY signal while data is being sampled. LOAD3 has no effect during this interval. BUSY goes high for approximately 15 microseconds.

DATA FORMATS

Input data may be presented by the external device in one of two forms. The first is seven digit binary-coded decimal (BCD) with a sign bit and decimal point code. The second is a 24-four bit binary word with a sign bit. The input bit assignments for each form is given in Figure 103-1.

OPERATION COMMANDS

Familiarity with the 2400B command set is necessary to make full use of the Digital Input assembly. Refer to the 2400B Programming Guide for detailed digital input measurement function information.

Installation Verification Test

To verify proper installation of the digital input assembly, use the following procedure. Refer to the 2400B Programming Guide for an explanation of the commands used below. For this test, the Digital Input must be equipped with either the Screw Terminal Connector (2400A-110), or Solder Pin Connector (2400A-111).

1. Remove any wires from the input connector.

2. Connect pins 12 and 14 of the input connector together.

3. Depress the POWER switch on the 2400B front panel.

4. Addressing the 2400B through the host device, enter the command:

   DEFN DICHAN = <channel #>, FORM = BINARY; !

   Where "channel #" is the card number assigned to the Digital Input assembly to be tested.

5. Enter the command:

   SEND DI(channel #) !

6. Verify that the value returned by the 2400B equals:

   -167772E7

7. Connect pin 48 on the connector to logic common.

8. Enter the command:

   SEND DI(channel #) !

9. Verify that the value returned equals:

   1.67772E7

10. This completes the Installation Verification Test.

Service Information

Calibration procedures, troubleshooting procedures, parts lists, schematics, and theory of operation are presented in the 2400B Service Manual.

OPTION 2400A-104 STATUS INPUT

Description

The Status Input assembly (Option 2400A-104) is a plug-in pcb assembly that allows the 2400B to accept up to 32 separate one-bit (high or low state) inputs from an external source. The inputs may come from switch closures or logic levels that show the status of external devices. Status Input assembly specifications are given in Table 104-1, and an equivalent circuit for the input is given in Figure 104-1.

The Status Input option is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. By using 2402A I/O Extender Chassis, up to 32 assemblies (1024 inputs) may be installed per system.

Input data is applied to the Status Input through a 50-pin, subminiature, D-Type connector that mates with the Screw Terminal Connector (Option 2400A-110), or the Solder Pin Connector (Option 2400A-111). The connectors provide the electrical connection to the external data source.

Table 104-1. Status Input Specifications

Maximum Number of Inputs Per Assembly	32 individually readable input bits.
Input Isolation	Inputs are isolated in common from the 2400 and/or ground up to 30V ac and 1.0 Volts/microsecond maximum slew rate.
Maximum Number of Inputs Per System	1024 (32 inputs per assembly, 32 assemblies per extended system).
Input Logic	Pull-up resistors are installed to allow contact closures and logic levels as inputs. The absence of a contact closure (pull down), or logical low, is read as a 1 (see Figure 104-1).
Logic Levels	Low power Schottky TTL inputs with static protection. $0 < Vin < 0.75$ for input Low. $2.5V < Vin < 8V$ for input High.
Power Consumption	12 watts per pcb added to the system.
Weight	0.4 kg. (1 lb.)
Environmental	Meets all the environmental specifications of the 2400

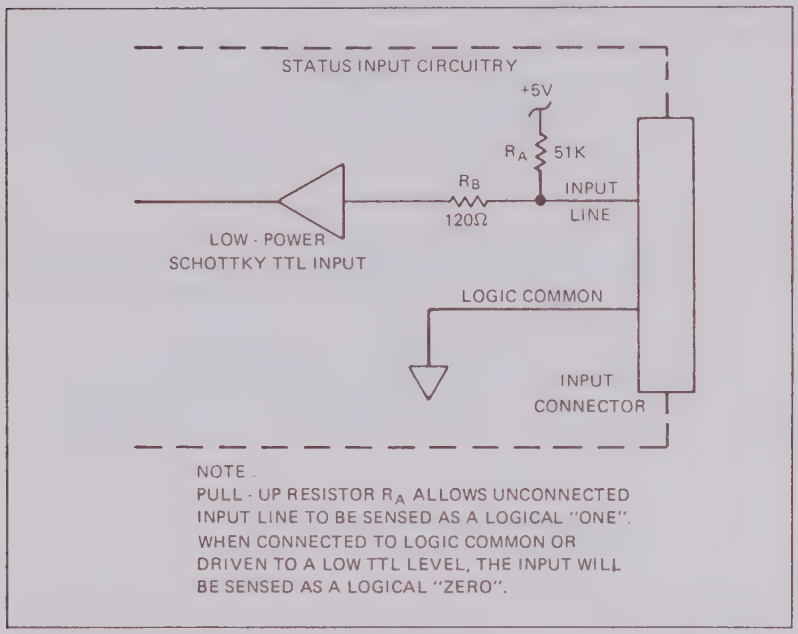

STATUS INPUT CIRCUITRY
+5V
R_A 51K
R_B
120Ω
INPUT LINE
LOW - POWER SCHOTTKY TTL INPUT
LOGIC COMMON
INPUT CONNECTOR
NOTE :
PULL - UP RESISTOR R_A ALLOWS UNCONNECTED INPUT LINE TO BE SENSED AS A LOGICAL "ONE". WHEN CONNECTED TO LOGIC COMMON OR DRIVEN TO A LOW TTL LEVEL, THE INPUT WILL BE SENSED AS A LOGICAL "ZERO".

Figure 104-1. Equivalent Circuit for One Status Input

Installation

The Status Input assembly mounts in any of the I/O option slots in the 2400B or 2402A as Figure 104-2 shows. To install the pcb, use the following procedure:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Remove the rear panel from the chassis.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

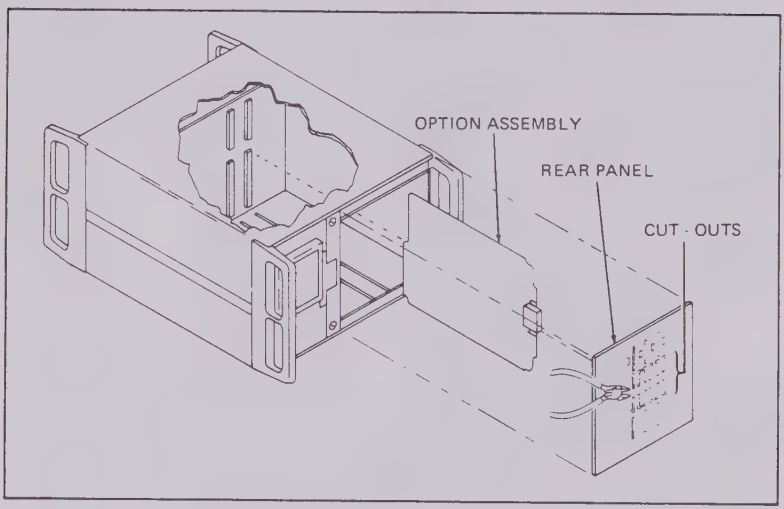


Figure 104-2. I/O Option Mounting Locations

4. To select the best I/O option slot for mounting the Status Input assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the pcb in the selected I/O option slot so that its card-edge connector is toward the front of the chassis, and the subminiature, D-type connector is toward the back. Push the pcb into the chassis mating connector.

6. Locate the Card Select Switches on the pcb as Figure 104-3 shows, and assign it a card number (consecutively for each option card, starting with 0) by setting the switches to the patterns shown in Table 104-2. The number selected will determine the input channels assigned to each pcb. Example: Card 0 provides inputs 0 through 31, Card 1 provides inputs 32 through 63, and so on.

7. Replace the rear panel, removing rear panel connector cutouts as necessary. Replace any cables and connectors removed in step 2. Attach the option identification decal to the rear panel as Figure 104-4 shows.

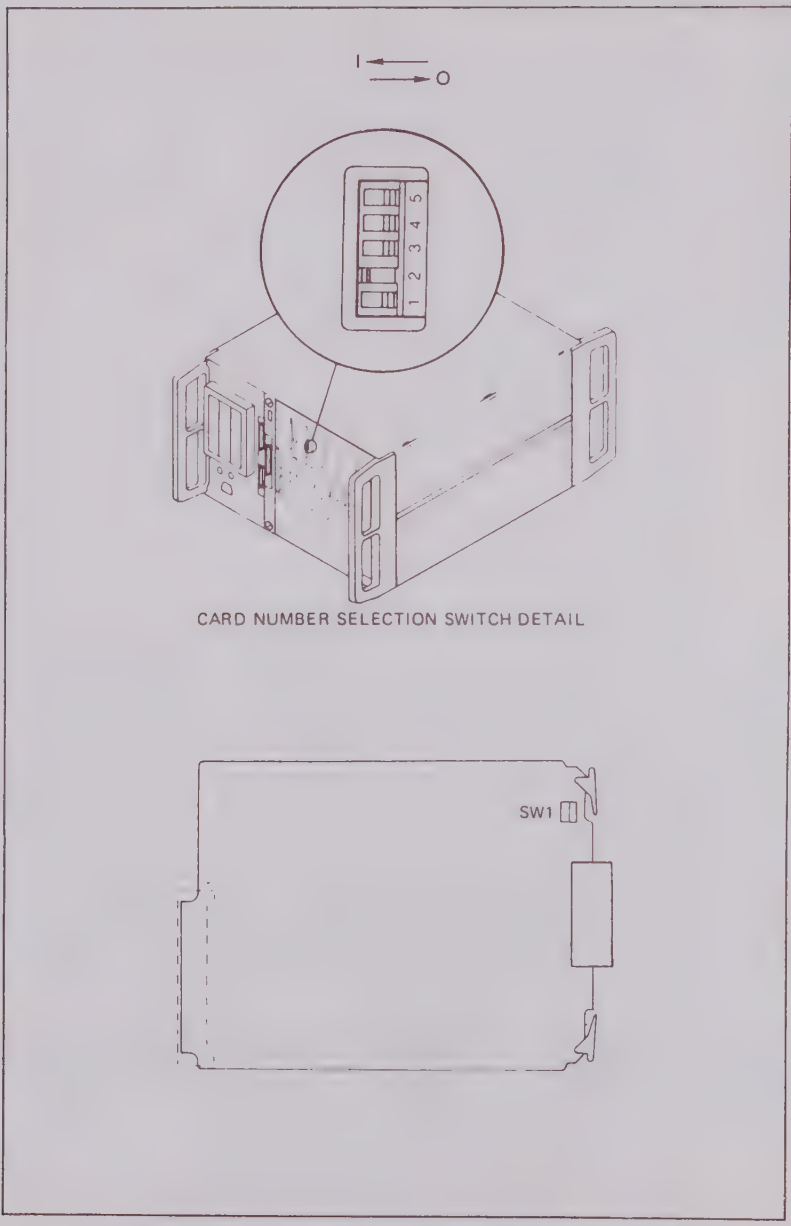


Figure 104-3. Card Select Switch Location

Table 104-2. Status Input Card Select Switch Settings

LEFT = ONE, RIGHT = ZERO S2 SWITCH SETTING = X X X X X						
Card Number	Card Switch Segments					Counter/Totalizer Channel Assigned
	B5	B4	B3	B2	B1	
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	0	0	1	0	2
3	0	0	0	1	1	3
4	0	0	1	0	0	4
5	0	0	1	0	1	5
6	0	0	1	1	0	6
7	0	0	1	1	1	7
8	0	1	0	0	0	8
9	0	1	0	0	1	9
10	0	1	0	1	0	10
11	0	1	0	1	1	11
12	0	1	1	0	0	12
13	0	1	1	0	1	13
14	0	1	1	1	0	14
15	0	1	1	1	1	15
16	1	0	0	0	0	16
17	1	0	0	0	1	17
18	1	0	0	1	0	18
19	1	0	0	1	1	19
20	1	0	1	0	0	20
21	1	0	1	0	1	21
22	1	0	1	1	0	22
23	1	0	1	1	1	23
24	1	1	0	0	0	24
25	1	1	0	0	1	25
26	1	1	0	1	0	26
27	1	1	0	1	1	27
28	1	1	1	0	0	28
29	1	1	1	0	1	29
30	1	1	1	1	0	30
31	1	1	1	1	1	31

Operation

Once installed in the chassis, the Status Input assembly is ready for use. Complete the external connections from the input connector to the source of status information. The Screw-Terminal Connector (Option 2400A-110) and the Solder-Pin Connector (Option 2400A-111) are available for this purpose. The pin assignments on the input connector are given in Table 104-3.

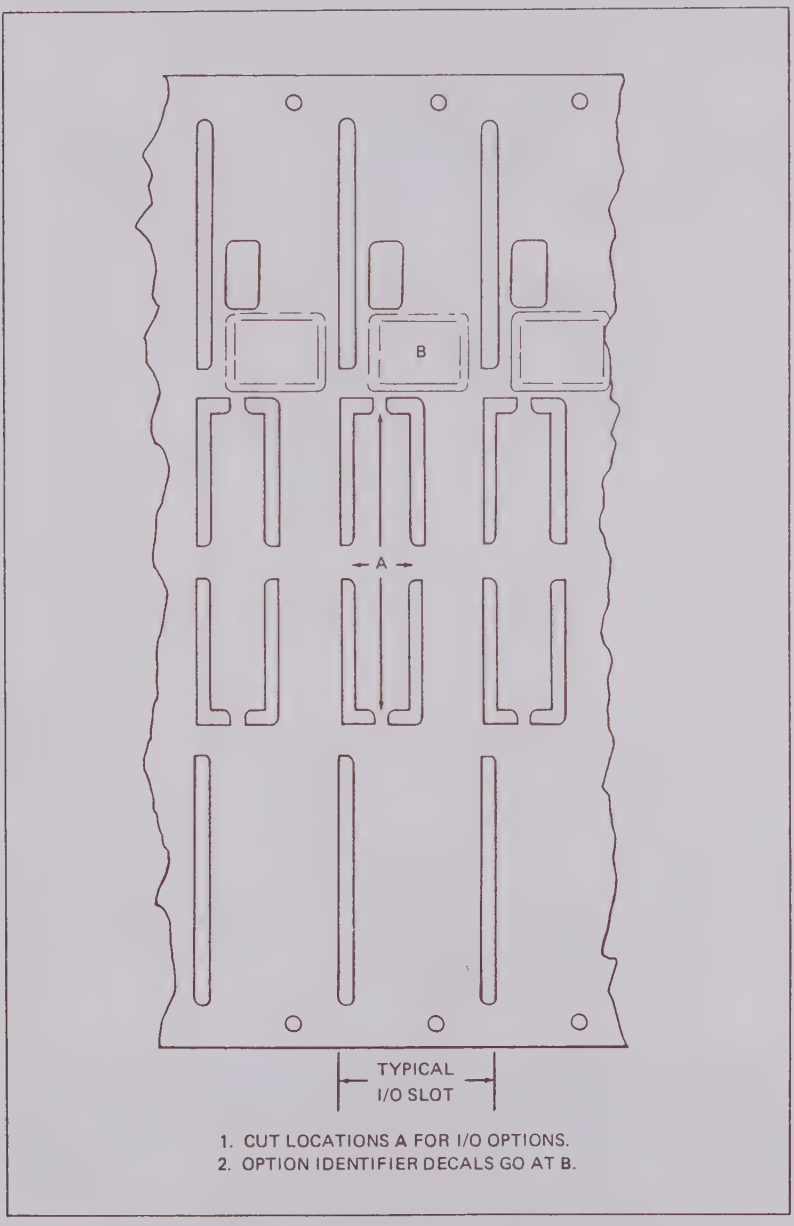


Figure 104-4. Rear Panel Detail

OPERATING COMMANDS

Familiarity with the 2400B command set is necessary to make full use of the Status Input assembly. Refer to the 2400B Programming Guide for more details on Status Input control function information.

Installation Verification Test

To verify proper installation of the assembly, two procedures can be used, depending on the hardware available. If the Status Output assembly (Option 2400A-301) is available, use Method 1, and if it is not, use Method 2. These approaches are detailed in order of preference. Refer to the Programming Guide for a detailed explanation of the commands used below:

METHOD 1

1. Install a Status Output assembly (2400A-301) in an I/O option slot in the 2400B. Install a connector on the output mating connector of the Status Output assembly. Using a test lead, connect pins 11 and 12 together.

2. Install a connector on the input mating connector of the Status Input assembly under test. Connect Isolated Common (pin 50) of the Status Input assembly to Isolated Common (pin 50) of the Status Output assembly. Connect a Status Input channel to the corresponding Status Output channel.

3. Apply power to the 2400B by depressing the POWER switch on the front panel.

4. Addressing the 2400B through the host device, enter the following command:

```
SEND SI(channel #)!
```

   Where "channel #" is the channel number assigned to the Status Input under test.

5. Verify that the value returned is a logical 0.

6. Enter the commands:

```
SO(channel #) = 1!
SEND SI(channel #)!
```

7. Verify that the value returned is a logical 1.

8. Enter the commands:

```
SO(channel #) = 0!
SEND SI (channel #)!
```

9. To complete the test, verify that the value returned is a logical 0.

METHOD 2

If a Status Output assembly is not available, use the following procedure:

1. Install a connector on the input mating connector on the back of the Status Input assembly.

2. Apply power to the 2400B by depressing the POWER switch on the front panel.

3. Addressing the 2400B through the host device, enter the following:

   SEND SI(channel #) !

   Where "channel #" is the channel number assigned to the Status Input channel to be tested.

4. Verify that the value returned by the 2400B is a logical 1.

5. Connect a test lead from the pin of the channel under test to Isolated Common (pin 50) on the connector. Enter the command:

   SEND SI(channel #) !

6. Verify that the value returned is a logical 0.

This completes installation verification for the Status Input assembly.

Service Information

Calibration procedures, troubleshooting procedures, parts lists, schematics and theory of operation information is presented in the 2400B Service Manual.

OPTION 2400A-110 SCREW TERMINAL CONNECTOR

Description

The Screw Terminal Connector is a general purpose connector assembly that attaches to several of the input/output (I/O) option assemblies. The connector mates with the 50-pin, subminiature, type-D connector on each option assembly, allowing easy wiring to external devices. Wiring connections are made using five 10-contact screw-terminal strips. The 50 contacts listed in Table 110-1 are numbered to correspond exactly to the pin-out of the D-connector. Contact voltages must be limited to less than 30 volts from earth ground for safety. Table 110-2 gives specifications for the Screw Terminal Connector.

Table 110-1. Screw Terminal Connector Pin Assignments

D CONNECTOR PIN	SOLDER PIN NUMBER	D CONNECTOR PIN	SOLDER PIN NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

Table 110-2. Screw Terminal Connector Specifications

Connector Type	General Purpose Input/Output
Compatibility	Mates with the following option assemblies: -103 Status Input -104 Digital Input -104/AA Sequence of Events Recorder -114 Interrupt Input -301 Status Output -302 Current/Voltage Analog Output
Number of Terminals	50 per assembly
Terminal Style	Screw type
Maximum Voltage	30 volts between any terminal and/or ground
Weight	0.2 kg. (0.5 lb.)
Environmental	Meets all the environmental specifications of the 2400B

Installation

The Screw Terminal Connector mates with any of the I/O option assemblies listed in Table 110-2. Install the connector as follows:

1. Set chassis POWER switch to OFF.
2. Locate the desired I/O option D-connector on the rear panel and check that the I/O option pcb is properly installed. Check the type of option and its card number.
3. Referring to Figure 110-1 and Table 110-1, attach external wiring to the Screw Terminal Connector as required for your application.
4. Insert the connector assembly into the mating D-connector.
5. Secure the connector to the I/O option circuit board using the strain relief screws provided.
6. Repeat the procedure for any additional I/O connectors.

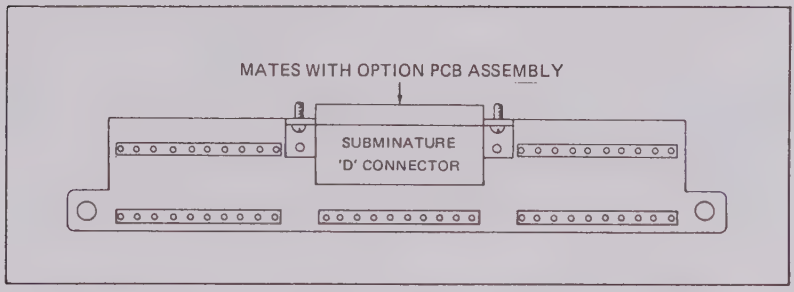


Figure 110-1. I/O Screw Terminal Connector

Operation

Once installed, the Screw Terminal I/O Connector is ready for use. No special operation steps are required.

Installation Verification and Performance Test

The most efficient way to verify correct installation of the I/O Connector, is to run through the verification test for the Input/Output assembly to which it is attached. Refer to the section of this guide describing the installation verification of the applicable I/O option.

Service Information

All applicable service information is provided in the 2400B Service Manual.

OPTION 2400A-111 SOLDER PIN CONNECTOR

Description

The Solder Pin Connector is a general purpose connector with a backshield. It is compatible with several of the input/output (I/O) option assemblies. The connector mates with the 50-pin, subminiature, type-D connector on each option assembly and provides solder terminals for wiring to external devices. The connections listed in Table 111-1 correspond exactly to the pin-out of the option connector. Contact voltages must be limited to 30 volts from earth ground. Specifications for the Solder Pin Connector are given in Table 111-2.

Table 111-1. Solder Pin Connector Pin Assignments

D CONNECTOR PIN	SOLDER PIN NUMBER	D CONNECTOR PIN	SOLDER PIN NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

Table 111-2. Solder Pin Connector Specifications

Connector Type	General Purpose Input/Output
Compatibility	Mates with the following option assemblies: -103 Status Input -104 Digital Input -104/AA Sequence of Events Recorder -114 Interrupt Input -301 Status Output -302 Current/Voltage Analog Output
Number of Terminals	50 per assembly
Terminal Style	Solder Pin
Maximum Voltage	30 volts between any terminal and/or ground
Weight	0.2 kg. (0.5 lb.)

Installation

The Solder Pin Connector mates with any of the I/O options listed in Table 111-2. Install the Solder Pin Connector as follows:

1. Set chassis POWER switch to OFF.
2. Locate the desired option I/O D-connector at the rear of the chassis and make sure the I/O option pcb is properly installed. Check the type of option and its card number.
3. Slip the connector backshield over the cable or wiring to be attached to the connector. Solder the wires to the Solder Pin Connector as required for the application.
4. Install the backshield on the connector.
5. Insert the connector assembly into the mating D-connector.
6. Secure the connector to the I/O option circuit board using the strain relief screws provided.
7. Repeat the procedure for any additional I/O connectors.

Operation

Once installed, the Solder Pin Connector is ready for use. No special operation steps are required.

Installation Verification and Performance Test

The most efficient way to verify correct installation of the Solder Pin Connector is to run through the installation verification test for the Input/Output assembly it is attached to. Refer to the section in this guide describing the installation verification test for the applicable I/O option.

Service Information

All applicable service information is included in the 2400B Service Manual.

OPTION 2400A-113 COUNTER/TOTALIZER

Description

The 2400A-113 Counter/Totalizer is a plug-in assembly that combines frequency, period, and interval measurement with a gateable bidirectional totalizer. The Counter/Totalizer provides several inputs including two frequency, period, and interval measurement inputs; two gating inputs; one trigger input; and four totalizer inputs.

All except one of the measurement inputs may include switch closures or logic levels and are not isolated from the 2400B or ground. The other of two inputs for measurement of frequency, period, and interval, may be a periodic analog signal. This input is isolated from the 2400B and ground. A single output indicates an overflow condition. The overflow output is a logic level and is not isolated from the 2400B or ground.

Several hardware functions on the Counter/Totalizer assembly provide system synchronization. Such functions include external triggering, single versus continuous measurement cycling, presettable bidirectional two-quadrant gateable totalizing, logic level gating, start-stop gating, and start-stop interval.

The Counter/Totalizer option is comprised of a connector and a single pcb assembly that mounts in any I/O option slot in the 2400B or 2402A chassis. By using 2402A extenders, a total of 32 Counter/Totalizers may be used in a system. The connector provided with the option is a 12-contact, screw-terminal type, and provides connection for all nine inputs, one output, isolated common, and non-isolated common. Specifications for the Counter/Totalizer Assembly are given in Table 113-1.

Table 113-1. Counter/Totalizer Specifications

NUMBER OF PCB ASSEMBLIES ...	32 PCB assemblies per extended system, maximum.
NONISOLATED INPUTS	TTL Input, Gate 1, Gate 2, Trigger, $\overline{\text{Count Up}}$, $\overline{\text{Count Down}}$, Up / $\overline{\text{Down}}$, $\overline{\text{Count}}$, Common (Nonisolated).
ISOLATED INPUTS	Analog Input and Common (Isolated). These inputs are isolated in common from the 2400 . and/or ground, up to 30V and 1.0 volt/microsecond maximum slew rate.

Table 113-1. Counter/Totalizer Specifications (cont.)

INPUT LOGIC	
Nonisolated Inputs	Pull-up resistors are installed to allow contact closures and logic levels as inputs.
Isolated Inputs (Analog Input)	Any periodic analog signal that satisfies signal level, frequency, duty cycle, and isolation requirements is allowed.
LOGIC LEVELS	All nonisolated inputs are low power Schottky inputs with static protection and a minimum of 400 mV of hysteresis. 0V to 0.5V for input low, 2.0V to 7V for input high.
$\overline{\text{OVERFLOW}}$ OUTPUT	
Output Isolation	The $\overline{\text{Overflow}}$ output is not isolated from the 2400 - or ground.
Output Circuitry	Open - collector TTL output.
Maximum Sink Current	40 mA.
Output Voltage	
AT 40 mA SINK CURRENT	0.7V max
AT 16 mA SINK CURRENT	0.4V max
Maximum OFF-State Voltage	30V
TTL Compatibility	The output can drive up to six standard TTL loads or up to twelve low-power Schottky loads. An external pull-up resistor is not required.
FREQUENCY MEASUREMENTS	
Inputs	TTL Input, Analog Input
Range	
NONISOLATED INPUT	0 to 900 kHz
ISOLATED INPUT	10 Hz to 200 kHz
Gate Times	
1	3.277 ms
2	26.21 ms
3	209.7 ms
4	3.355 sec
Resolution	
1	305 Hz
2	38.2 Hz
3	4.77 Hz
4	0.298 Hz
Accuracy	±1 count ± timebase accuracy
PERIOD MEASUREMENTS	
Inputs	TTL Input, Analog Input, Gate 1, Gate 2

Table 113-1. Counter/Totalizer Specifications (cont.)

Range	
NONISOLATED INPUT	0.15 Hz to 900 kHz
ISOLATED INPUT	10 Hz to 200 kHz
Frequency Counted	2.50 MHz
Resolution	400 ns
Accuracy	±1 count ± timebase accuracy ± trigger error of signal on input.
TIME INTERVAL MEASUREMENTS	
Inputs	TTL Input, Analog Input, Gate 1, Gate 2
Range	
NONISOLATED INPUT	
Fast Rate	1.2 μs to 6.7s
Slow Rate	819 μs to 1.37x10 4s (3.82 hr)
ISOLATED INPUT	2.5 μs to 50 ms
Frequency Counted	
FAST RATE	2.5 MHz
SLOW RATE	1.221 kHz
Resolution	
FAST RATE	400 ns
SLOW RATE	819 μs
Accuracy	±1 count ± timebase accuracy ± trigger error
TOTALIZE	
Count Inputs	$\overline{\text{Count Up}}$, $\overline{\text{Count Down}}$, $\overline{\text{Count}}$, Up / $\overline{\text{Down}}$
Gate Inputs	Gate 1, Gate 2
Range	DC to 900 kHz
Capacity	-8,388,608 to +8,388,607
ANALOG INPUT SENSITIVITY	
Sinewave	
10 Hz to 100 kHz	50 mV rms
100 kHz to 200 kHz	100 mV rms
Pulse	150 mV with minimum pulse width of 2.5 μs. 5% < duty cycle < 95%.
ANALOG INPUT IMPEDANCE	
Nonlimiting	10 megohm, ≤50 pF
Limiting	1.2 megohm in parallel with 47 pF
TIMEBASE	
Frequency	10.000 MHz
Accuracy	±50 ppm

Table 113-1. Counter/Totalizer Specifications (cont.)

NONISOLATED IMPUT TIMING	See Figure 113-3
Trigger Input	
TRIGGERABLE MODES	Period, Frequency, Time Interval
PULSE WIDTH (Tpw)	100 ns min.
Input Debouncing	
INDIVIDUALLY DEBOUNCEABLE INPUTS (SWITCH SELECTABLE)	$\overline{\text{Count}}$, $\overline{\text{Count Up}}$, $\overline{\text{Count Down}}$, Gate 1, Gate 2
INPUT PULSE WIDTH TO CHANGE STATE (Tip)	15 ms min.
BOUNCE PULSE WIDTH (Tbp) .	10 ms max.
Measurement Input Timing (All Debouncers Off)	
APPLICABLE INPUTS	TTL Input, Gate 1, Gate 2, $\overline{\text{Count}}$, $\overline{\text{Count Up}}$, $\overline{\text{Count Down}}$, Trigger
INPUT PULSE WIDTH EXCEPT TRIGGER (Tpw)	500 ns min.
TRIGGER SET-UP TIME IN TIME INTERVAL OR PERIOD MODES (TTRsu)	1.0 μs minimum to guarantee that the period or time interval immediately following the trigger is the one measured.
GATE 1- TO -GATE 2 OR GATE 2- TO -GATE 1 SEPARATION (TGGsep)	500 ns minimum to guarantee that the positive edge of one input is recognized as occurring before the other.
GATE TO COUNT OR COUNT TO GATE SEPARATION (TGCsep)	1.0 μs minimum to guarantee that count pulses are totalized after the gate enables the totalizer and not before, and that count pulses are totalized before the gate disables the totalizer and not after.
UP/DOWN INPUT STABLE SET-UP (TDsu)	0 ns minimum prior to Count.
UP/DOWN INPUT STABLE HOLD (TDhld)	1.0 μs minimum after Count.
POWER CONSUMPTION	12 watts typical per PCB assembly added to the system.
WEIGHT	0.4 kg (1.0 lb)
ENVIRONMENTAL	Meets all the environmental specifications of the 2400

Installation

The Counter/Totalizer mounts in any of the I/O option slots in the 2400B or 2402A as Figure 113-1 shows. Install the Counter/Totalizer as follows:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE-POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

3. Locate the Card Select Switches on the pcb as Figure 113-2 shows, and assign it a card number (consecutively, starting with 0, for each option card) by setting the switches to the patterns shown in Table 113-2. The number selected will determine the input channels assigned to each pcb. Example: Card 0 provides channel 0, Card 1 provides channel 1, and so on.

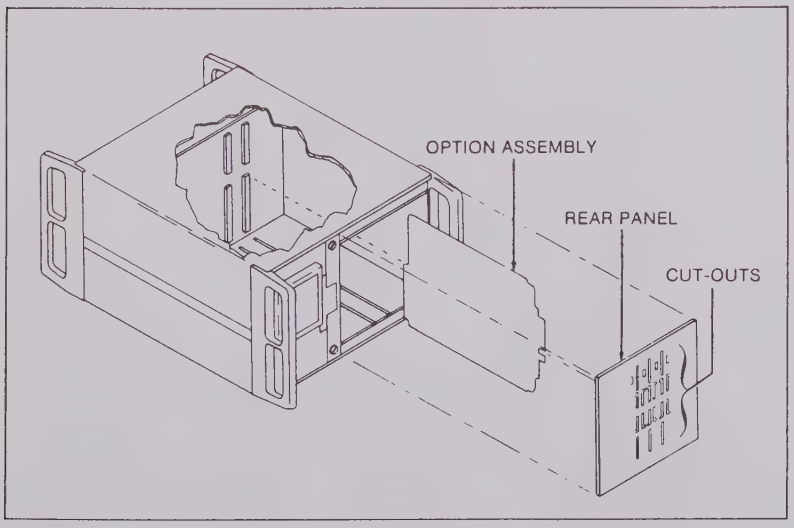


Figure 113-1. Counter/Totalizer Mounting Locations

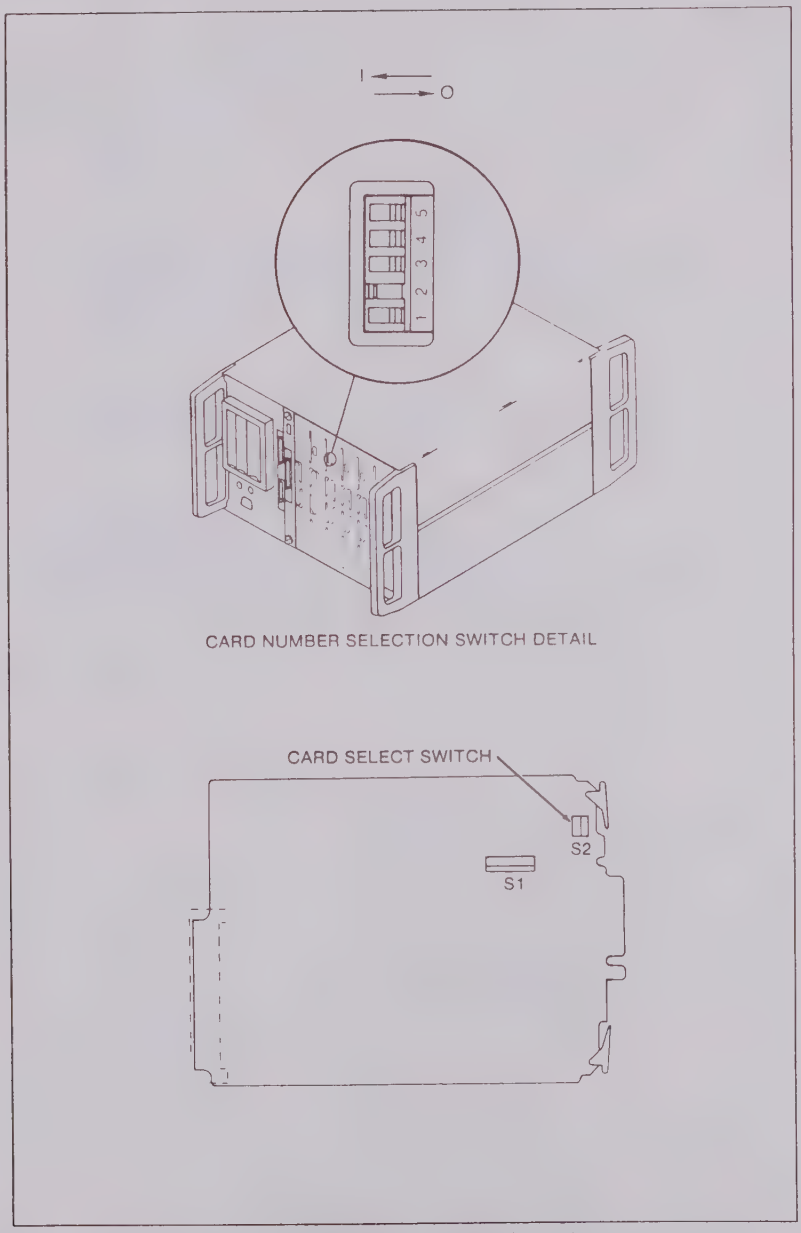


Figure 113-2. Card Select Switch Location

Table 113-2. Counter/Totalizer Card Selection Switch Settings

LEFT = ONE, RIGHT = ZERO S2 SWITCH SETTING = X X X X X						
Card Number	Card Switch Segments					Counter/Totalizer Channel Assigned
	B5	B4	B3	B2	B1	
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	0	0	1	0	2
3	0	0	0	1	1	3
4	0	0	1	0	0	4
5	0	0	1	0	1	5
6	0	0	1	1	0	6
7	0	0	1	1	1	7
8	0	1	0	0	0	8
9	0	1	0	0	1	9
10	0	1	0	1	0	10
11	0	1	0	1	1	11
12	0	1	1	0	0	12
13	0	1	1	0	1	13
14	0	1	1	1	0	14
15	0	1	1	1	1	15
16	1	0	0	0	0	16
17	1	0	0	0	1	17
18	1	0	0	1	0	18
19	1	0	0	1	1	19
20	1	0	1	0	0	20
21	1	0	1	0	1	21
22	1	0	1	1	0	22
23	1	0	1	1	1	23
24	1	1	0	0	0	24
25	1	1	0	0	1	25
26	1	1	0	1	0	26
27	1	1	0	1	1	27
28	1	1	1	0	0	28
29	1	1	1	0	1	29
30	1	1	1	1	0	30
31	1	1	1	1	1	31

4. To select the best I/O option slot for mounting the Counter/Totalizer, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the pcb assembly in the selected I/O option slot so that its larger card-edge connector is toward the front of the chassis, and its smaller, 12-contact card-edge connector is toward the back of the unit (see Figure 113-1). Push the pcb assembly into the chassis mating connector.

6. After the Counter/Totalizer assembly is installed, replace the rear panel, removing the rear panel connector cut-out as necessary. Attach the option identification decal to the rear panel.

7. Replace any cables disconnected from the back panel in step 2.

Remote Source Connections

Once installed in the chassis, the Counter/Totalizer assembly is ready for use and requires no operator attention. However, you must consider certain details to properly interface the assembly with remote source input signals. These details are covered in the following paragraphs. You must also complete the cable and pin connections to the remote source(s). Use the 12-terminal connector on the back of the Counter/Totalizer for connections. Table 113-3 lists the connector pin assignments and Table 113-1 lists signal level and timing specifications. Refer to Figure 113-3 for more timing details of Counter/Totalizer operation.

Modes of Operation

The remote sources can be viewed as three distinct and functionally different input channels (totalizer, TTL input, and analog input). Each of the channels share some inputs and the single output. Table 113-4 lists these input channels with their inputs, outputs, and operating modes. The Counter/Totalizer is programmed to measure any of the three channels. In addition, Gate 1 and Gate 2 inputs can be used as a fourth input channel if they are not needed for gating the totalizer channel. In such a case, the remote sources can be viewed as four functionally different channels as listed in Table 113-5.

Table 133-3. Counter/Totalizer Assembly Connector Terminal Assignments

TERMINAL	SIGNAL	COMMON TERMINAL
1	Common (Isolated)	N.A.
2	Analog Input	1
3	$\overline{\text{Overflow}}$	12
4	Gate 1	12
5	Gate 2	12
6	Trigger	12
7	$\overline{\text{Count Up}}$	12
8	$\overline{\text{Count Down}}$	12
9	Up / $\overline{\text{Down}}$	12
10	$\overline{\text{Count}}$	12
11	TTL Input	12
12	Common (Non-isolated)	N.A.

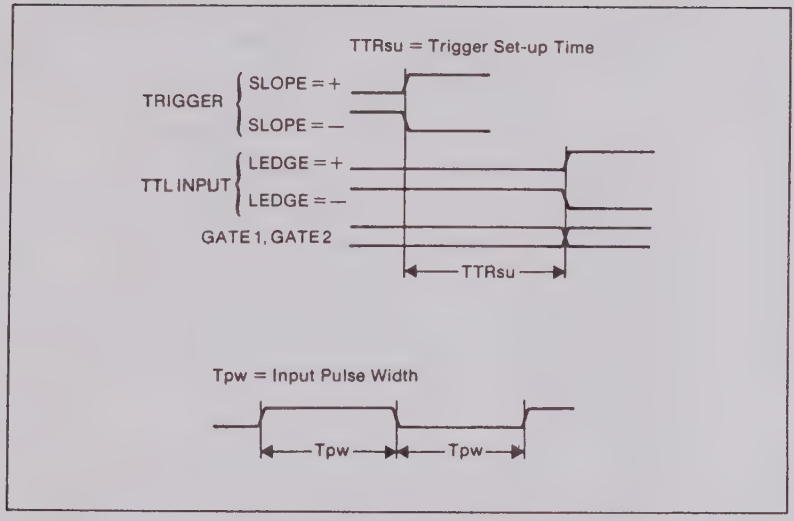


Figure 113-3. Counter/Totalizer Non-Isolated Input Timing

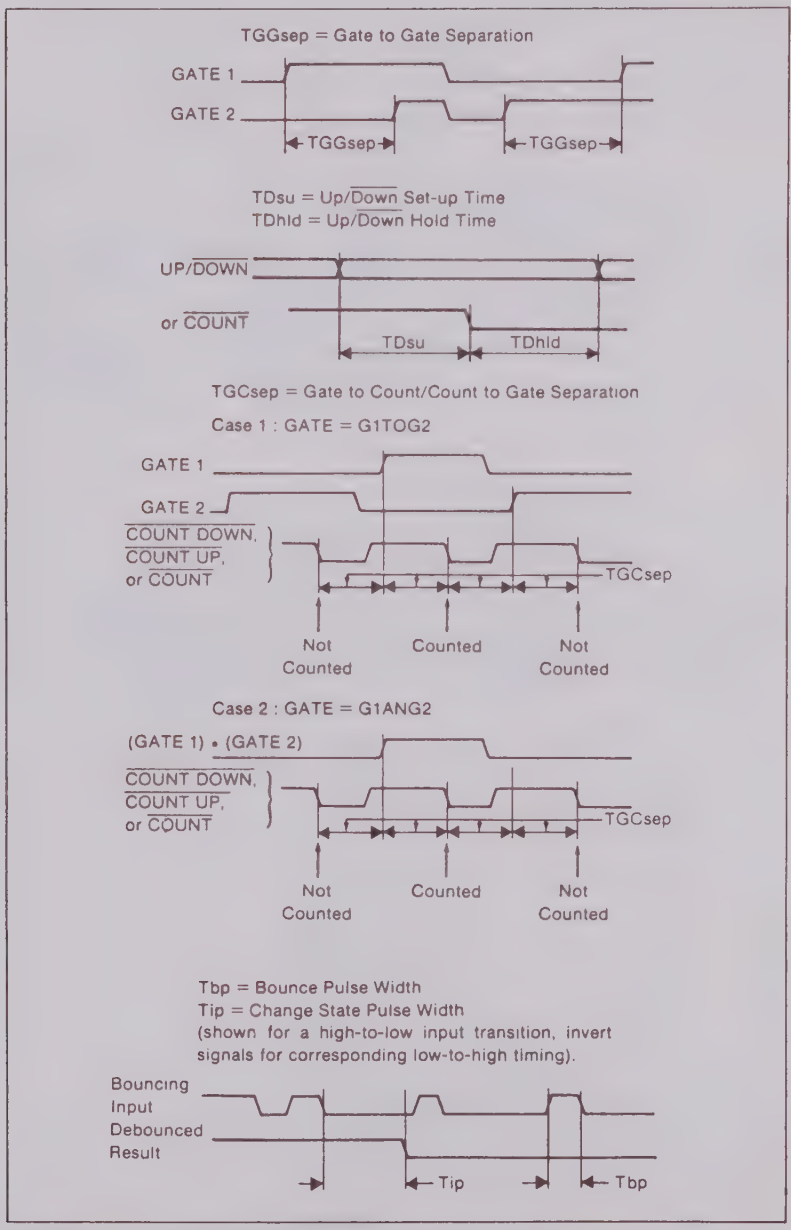


Figure 113-3. Counter/Totalizer Non-Isolated Timing (cont.)

Table 113-4. Input Channel List (Gated Totalizing)

INPUT CHANNEL	DEDICATED INPUTS	SHARED INPUTS OUTPUT	MODES AVAILABLE
Totalizer	Count Up Count Down Count Up / Down Gate 1 Gate 2	Overflow Common (Non-Isolated)	Totalizing
TTL Input	TTL Input	Trigger Overflow Common (Non-Isolated)	Period Frequency Time Interval - Fast Rate
Analog Input	Analog Input Common (Isolated)	Trigger Overflow Common (Non-Isolated)	Period Frequency Time Interval - Fast Rate

Table 113-5. Input Channel List (Ungated Totalizing)

INPUT CHANNEL	DEDICATED INPUTS	SHARED INPUTS, OUTPUT	MODES AVAILABLE
Totalizer	Count Up Count Down Count Up / Down	Overflow Common (Non-isolated)	Ungated Totalizing
TTL Input	TTL Input	Trigger Overflow Common (Non-isolated)	Period Frequency Time Interval - Fast Rate
Analog Input	Analog Input Common (Isolated)	Trigger Overflow Common (Non-isolated)	Period Frequency Time Interval - Fast Rate
Events	Gate 1 Gate 2	Trigger Overflow Common (Non-isolated)	Time Interval - Slow Rate Time Interval - Fast Rate Period

TOTALIZER OPERATION

General

While totalizing, the TTL Input, Analog Input, and Trigger Input have no effect. When the totalizer is enabled, a negative transition (falling edge) on a count input to the bidirectional totalizer causes it to either increment or decrement.

Count Up, Count Down Inputs

A negative transition at the Count Up input (terminal 7) causes the totalizer to increment once. A negative transition at the Count Down input (terminal 8) causes the totalizer to decrement once. Positive transitions and simultaneous negative transitions at both Count Down and Count Up have no effect on totalizer count.

Count, Up/Down Inputs

The Up/Down input (terminal 9) determines whether a negative transition on the Count input (terminal 10) will increment or decrement the totalizer value. That is, if Up/Down is high when a negative transition at the Count input occurs, the totalizer will increment once. Conversely, if Up/Down is low during the negative transition at the Count input, the totalizer will decrement once. Positive transitions at the Count input and any legal transitions at the Up/Down input have no effect on the accumulated total. The Up/Down input should be stable during a negative edge at the Count input.

Count Up, Count Down Inputs Versus Count, Up/Down Inputs

The Count Up and Count Down inputs form a bidirectional counting pair; the Count and Up/Down inputs form another pair. The two counting pairs are not intended to be used simultaneously. If only one pair is to be used, the unused pair is left unconnected. If both pairs are to be used at different times, care must be taken to observe the following rules:

- If the Count Up and Count Down inputs are being used, the Count input must be high or unconnected. The Up/Down input has no effect.

- If the Count and Up/Down inputs are being used, both Count Up and Count Down must be high or unconnected.

Gate Inputs

The totalizer can be enabled and disabled by external events applied to the Gate 1 (terminal 4) and Gate 2 (terminal 5) inputs. Either the levels or the transitions applied to these inputs are significant, depending on the mode selected. Also, external gating can be disabled such that the Gate 1 and Gate 2 inputs have no effect on totalizer operation.

GATE 1 TO GATE 2 OPERATION

During Gate 1 to Gate 2 totalizer operation, transitions at Gate 1 and Gate 2 inputs are significant. A positive transition at the Gate 1 input is interpreted as the start signal, and a positive transition at the Gate 2 input is interpreted as the stop signal. A positive transition at the Gate 1 input enables the totalizer if it is disabled, while a positive transition at Gate 2 input disables the totalizer if enabled. Positive transitions at the Gate 1 input with the totalizer enabled, positive transitions at the Gate 2 input with it disabled, and negative transitions at either the Gate 1 or Gate 2 input have no effect on operation.

GATE 1 AND GATE 2 OPERATION

During Gate 1 and Gate 2 totalizer operation, the levels at the Gate 1 and Gate 2 inputs are significant. The totalizer is enabled when both inputs are made logic high or left unconnected. The totalizer is disabled when either the Gate 1 or Gate 2 input is made logic low.

GATING DISABLED

If external gating is disabled, the Gate 1 and Gate 2 inputs have no effect on totalizer operation. If the Gate 1 and Gate 2 inputs are not used for totalizer gating, they can be used as a fourth channel to time external events (see Table 113-5). This mode also makes it possible to gain information on the effect that external gating has on the totalizer for a given process.

Input Debouncing

Debouncing eliminates the risk of counting mechanical contact bounces when the option is totalizing contact closures. A reading is debounced by waiting for a minimum pulse width after each input transition to reject the contact bounce pulses. At the end of the timing pulse the input is accepted as having changed states. The following inputs can be individually selected for debouncing: Count, Count Up, Count Down, Gate 1, and Gate 2. Debouncing selection is done by locating the debounce enable switches and setting them as desired according to Table 113-6.

Table 113-6. Input Debouncing Switch Settings

UP = ON, DOWN = OFF S1 Switch Settings		
NUMBER	**CARD LABEL**	**INPUT DEBOUNCED**
S1-1	CD	$\overline{\text{Count Down}}$
S1-2	CU	$\overline{\text{Count Up}}$
S1-3	G1	Gate 1
S1-4	G2	Gate 2
S1-5	C	$\overline{\text{Count}}$

Overflow Output

During totalizing, the Overflow output (terminal 3) shows when there is an overflow condition. If the totalizer overflows (or underflows), the Overflow output goes low until overflow status is reset. When the Overflow output is high, the Counter/Totalizer shows a no overflow condition.

COUNTING

The counting function operates in any one of four basic counting modes: Frequency, Period, Interval - Slow Rate, and Interval - Fast Rate. Each of these modes is described in the following paragraphs.

Frequency

In the Frequency mode the Counter/Totalizer counts input pulses during a specified gate time. Both the TTL Input and the Analog Input are available for frequency counting. During operation in the frequency counter mode, the Trigger input can be used to trigger new measurements. (The Trigger input is described under the heading Trigger Input.) Also during operation in this mode, the Overflow output goes low when the measurement overflows, and stays low until the next measurement is initiated. (In frequency counter mode, the Count, Up/Down, Count Up, Count Down, Gate 1, and Gate 2 inputs have no effect on operation.)

Period

In the Period mode, the Counter/Totalizer measures the interval between successive transitions of the same polarity at the input. The available inputs are: TTL Input, Analog Input, and the combination of the Gate 1 and Gate 2 inputs. Period measurements of the TTL Input or the Analog Input can be initiated on either the falling edge of the input or on the rising edge. Period measurements made with the combination of the Gate 1 and Gate 2 inputs may be either Gate 1-to-Gate 2 or Gate 1-and-Gate 2. Leading edge specifications have no meaning in either case.

A Gate 1-to-Gate 2 period measurement begins with a rising edge at the Gate 1 input. Further positive transitions at the Gate 1 input have no effect until a positive transition at the Gate 2 input has occurred. The first positive transition at the Gate 2 input after at least one positive transition at the Gate 1 input completes the period measurement. After the period measurement is completed, a positive transition at the Gate 1 input is required before the next period measurement can be initiated.

A Gate 1-and-Gate 2 period is initialized with a negative transition at either the Gate 1 or Gate 2 input if both were previously high (i.e., when the logical AND of the Gate 1 and Gate 2 inputs becomes false). Both Gate 1 and Gate 2 inputs must be made high simultaneously to begin the period measurement. The measurement is completed when either the Gate 1 or Gate 2 input is made low.

The Trigger input, described under the heading Trigger Input, can be used to trigger new period measurements. The Overflow output goes low if the period measurement overflows, and stays low until the next period measurement is started. During period measurements, signals applied to the Count, Up/Down, Count Up, and Count Down have no effect on operation.

Interval-Slow Rate

During Interval-Slow Rate mode, only the Gate 1 and Gate 2 inputs are used. In this mode, the counter is switched to run on a much slower time base. As a result, long intervals can be measured. Also the Gate 1 and Gate 2 inputs are interpreted as either Gate 1-to-Gate 2, or Gate 1-and-Gate 2. Leading edge specifications have no meaning in either case. An interval measurement using the Gate 1-to-Gate 2 mode begins with a positive edge at the Gate 1 input and stops with a positive edge at the Gate 2 input. Interval measurement using Gate 1 and Gate 2 starts when both Gate 1 and Gate 2 become high and stops when either one goes low. The Trigger input can be used to trigger new measurements, as described under the heading Trigger Input. The Overflow output goes low if the interval measurement overflows, and stays low until the next measurement is started. During Interval-Slow Rate measurements, signals to the Count, Up/Down, Count Up, Count Down, TTL, and Analog inputs have no effect on operation.

Interval-Fast Rate

During operation in the Interval-Fast Rate mode, the counter runs at its maximum speed. The available inputs in this mode are the TTL Input, the Analog Input, and the combination of the Gate 1 and Gate 2 inputs. For both the TTL Input and the Analog Input, the counter measures the interval between successive input transitions of opposite polarity. If the positive leading edge is specified, measurement begins on the rising edge and stops on the falling edge. If the negative leading edge is specified, measurement begins on the falling edge and stops on the rising edge. Measurement of Gate 1-to-Gate 2 begins with a positive edge at the Gate 1 input and stops with a positive edge at the Gate 2 input. Measurement of Gate 1-and-Gate 2 starts when both the Gate 1 and Gate 2 inputs are made high, and stops when either one is made low.

The Trigger input can be used to trigger an interval measurement, as described under the heading Trigger Input. The Overflow output goes low if the interval measurement overflows, and stays low until the next measurement is started. During Interval-Fast Rate measurement, signals applied to the Count, Up/Down, Count Up, and Count Down inputs have no affect on operation.

Trigger Input

The Trigger input can be optionally used to externally trigger new measurements in all counter modes (Period, Frequency, Interval-Slow Rate, and Interval-Fast Rate). Selection may be made of either a positive edge or a negative edge for external trigger. In either case,

the Trigger input is shared among the TTL Input, Analog Input, and Gate 1 and Gate 2 inputs.

Overflow Output

During operation in all counter modes, a low output on Overflow shows that an overflow has occurred on the measurement in progress. The output will remain low until a new measurement is initiated, then the overflow status is cleared and the output goes high.

Familiarity with the command set of the 2400B is necessary to properly exercise the Counter/Totalizer assembly. Refer to the 2400B Programming Guide for detailed information about operating this option.

Installation Verification Test

To verify proper installation of the Counter/Totalizer assembly, use the following procedure. Refer to the 2400B Programming Manual for a complete explanation of the commands used below.

1. Remove all wires from the input connector.

2. Depress the POWER switch on the front panel of the 2400B.

3. Addressing the 2400B through the host device, enter the command:

```
DEFN CTCHAN = <channel #>, TYPE = TOTAL;!
```

   Where "channel #" is the card number assigned to the Counter/Totalizer to be tested.

4. Enter the command:

```
SEND CTI(channel #)!
```

5. Verify that the value returned by the 2400B equals 0.

6. Enter the sequence of commands:

```
CTS(channel #)=0!
CTI(channel #)=500!
```

7. Enter the command:

```
SEND CTI(channel #)!
```

8. Verify that the value returned by the 2400B equals 500.

9. This completes the Installation Verification Test.

Service Information

Calibration procedures, troubleshooting procedures, parts lists, schematics, and theory of operation are presented in the 2400B Service Manual.

OPTION 2400A-114 INTERRUPT INPUT

Description

The Interrupt Input Assembly (Option 2400A-114) is a plug-in assembly that allows the 2400B to accept up to 16 separate one-bit inputs from an external source. The inputs may be switch closures or logic levels showing the status of external devices. Each 2400B system can accept up to two Interrupt Input Assemblies.

The Interrupt Input option is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. A maximum of two Interrupt Input assemblies (32 total inputs) may be installed in the system.

Input data is applied through a 50-pin, subminiature, D-type connector that mates with the Screw Terminal Connector (Option 2400A-110) or the Solder Pin Connector (Option 2400A-111). The connectors provide the electrical connection to the external data source.

Table 114-1 lists the Interrupt Input Assembly specifications, and Figure 114-1 gives an equivalent circuit of an Interrupt Input channel.

Installation

During installation, each channel of the Interrupt Input Assembly can be configured for either direct input mode or debounced input mode by means of 16 individual switches mounted on the PCB assembly (in groups of five plus one). If debounced mode is selected, the input must maintain a stable logic level for a specific interval (called the debounce time) before the input transition is recognized. Selecting debounced mode prevents the Interrupt Input assembly from interpreting multiple transitions caused by contact bounce on such mechanical devices as switches and relays as multiple interrupts.

The Interrupt Input Assembly mounts in any of the I/O option slots in the 2400B or the 2402A. Use the following procedure to install the pcb:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRICAL SHOCK REMOVE LINE-POWER AND ALL OTHER HIGH VOLTAGE INPUTS FROM THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

Table 114-1. Interrupt Input Specifications

MAXIMUM NUMBER OF INPUTS	
Per Assembly	16 individually configured input bits.
Per System	32 (16 inputs per assembly, 2 assemblies per system.) See Figure 114-1.
INPUT LOGIC	Pull-up resistors are installed to allow contact closures and logic level inputs. A contact closure is sensed as logical 0.
LOGIC LEVELS	Low power Schottky TTL inputs with static protection.
Logic 0	0 to 0.75V
Logic 1	2.5V to 7V
INPUT CONFIGURATION	Configured individually as a direct input or a debounced input by 16 SPDT switches on the -114 Assembly.
DIRECT INPUT RESPONSE	Signal must be stable for a minimum of 15 microseconds before and after the occurrence of the desired edge to detect the transition.
DEBOUNCED INPUT RESPONSE	Five nominal debounce periods from 5 ms to 88 ms are available thru switch selection. The selected debounce period is common for all debounced inputs on an assembly. Each debounced input must be stable for the selected period before and after a transition.
SOURCE CONTACT RESISTANCE (FOR CONTACT SENSE)	
HI (Contact Open)	≥47 kilohms
LO (Contact Closed)	≤1 kilohm
INPUT ISOLATION	Inputs are isolated on common from the 2400 and/or ground up to 30 Volts and 1.0 volt/microsecond maximum slew rate.
POWER CONSUMPTION	10 watts/pcb added to the system.
WEIGHT	0.4 Kg (1 lb.)
ENVIRONMENTAL	Option -114 meets all environmental specifications of the 2400

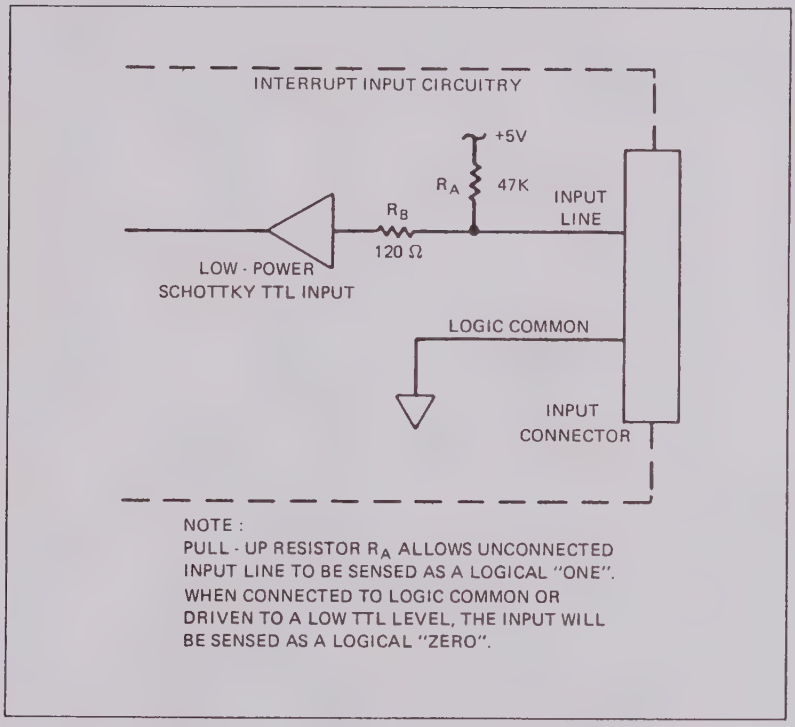


Figure 114-1. Equivalent Circuit for One Interrupt Input

3. Select either direct or debounced configuration for each input channel. Examine the component side of the printed circuit board and locate switches S2 through S5 (referring to in Figure 114-2). Set each of the top 16 switches to the position corresponding to the type of external input information connected to that channel. For the direct input mode, set the switch to the right. Set the switch to the left for the debounced input mode.

4. For input channels with the debounced mode selected, select a nominal debounce time by setting switch positions S5-2 through S5-5. Table 114-2 contains the switch settings and their corresponding debounce times, which range from 5.5 ms to 87.4 ms.

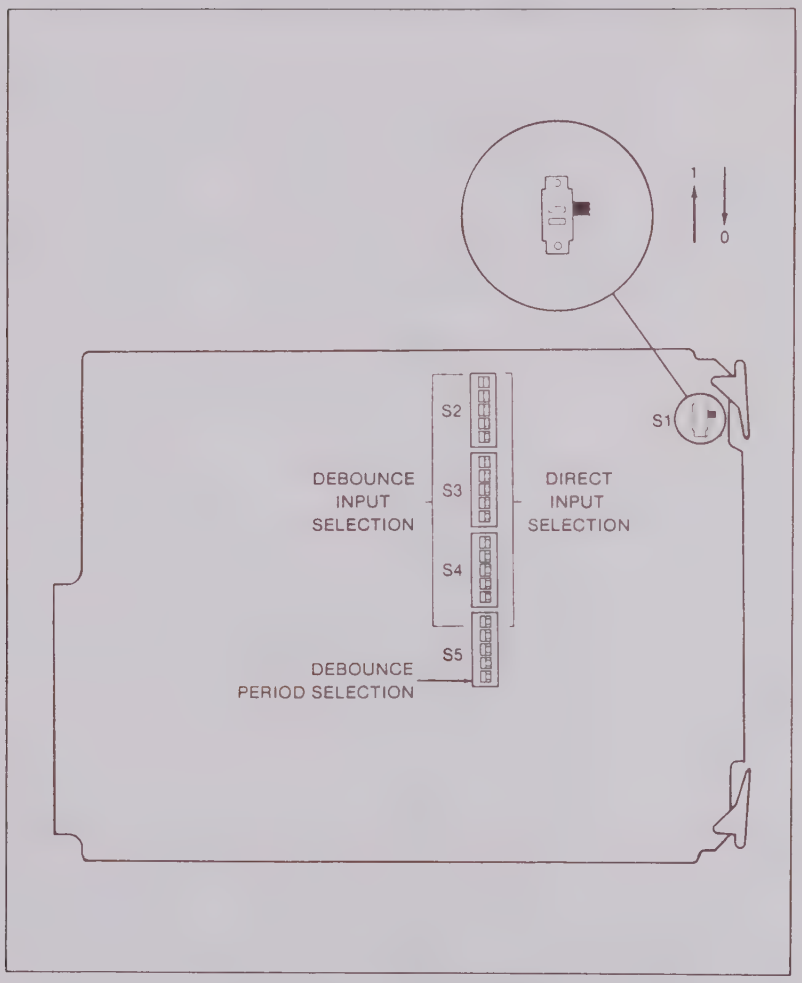


Figure 114-2. Switch Locations

5. To select the best I/O option slot for mounting the Interrupt Input assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation, of this guide.

6. Align each pcb in its selected I/O option slot so that its card-edge connector is toward the front of the chassis, and its subminiature, D-type connector is toward the back (see Figure 114-3). Push the pcb into the chassis mating connector.

Table 114-2. Debounce Switch Location

DEBOUNCE PERIOD ±12.5%	X = DON'T CARE			
	S5-2 POSITION	S5-3 POSITION	S5-4 POSITION	S5-5 POSITION
5.5 ms	5	11	11	11
10.9 ms	11	11	11	11
21.8 ms	X	22	11	11
43.7 ms	X	X	44	11
87.4 ms	X	X	X	88

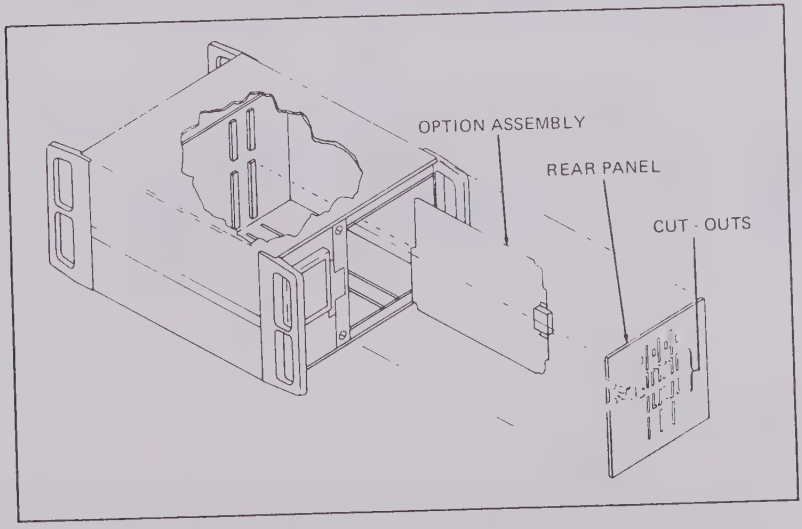


Figure 114-3. I/O Option Mounting Locations

7. Locate the Card Select Switch on each pcb (shown in Figure 114-2). Assign card numbers to each pcb by setting the switch as Table 114-3 shows. The number selected will determine the input channels assigned to each pcb. Card 0 provides inputs 0 through 15, while Card 1 provides inputs 16 through 31.

Table 114-3. Interrupt Input Card Address Switch Settings

UP = ONE, DOWN = ZERO S1 SWITCH SETTINGS = X		
CARD NUMBER	POSITION	INTERRUPT INPUT CHANNELS ASSIGNED
0	0	0-15
1	1	16-31

Note

If only one Interrupt Input option is installed, it must be assigned as Card 0.

8. After the Interrupt Input Assembly is installed, install the rear panel, removing the rear panel connector cut-out as necessary. Attach the option identification decal to the rear panel as shown in Figure 114-4.

Operation

Once installed in the chassis, the Interrupt Input assembly is ready for use. Complete the external connections from the input connector to the source of status information. The Screw-Terminal Connector (Option 2400A-110) and the Solder-Pin Connector (Option 2400A-111) are available for this purpose. The pin assignments on the input connector are given in Table 114-4. Refer to the 2400B Programming Guide for detailed Interrupt Input control function and 2400B command set information.

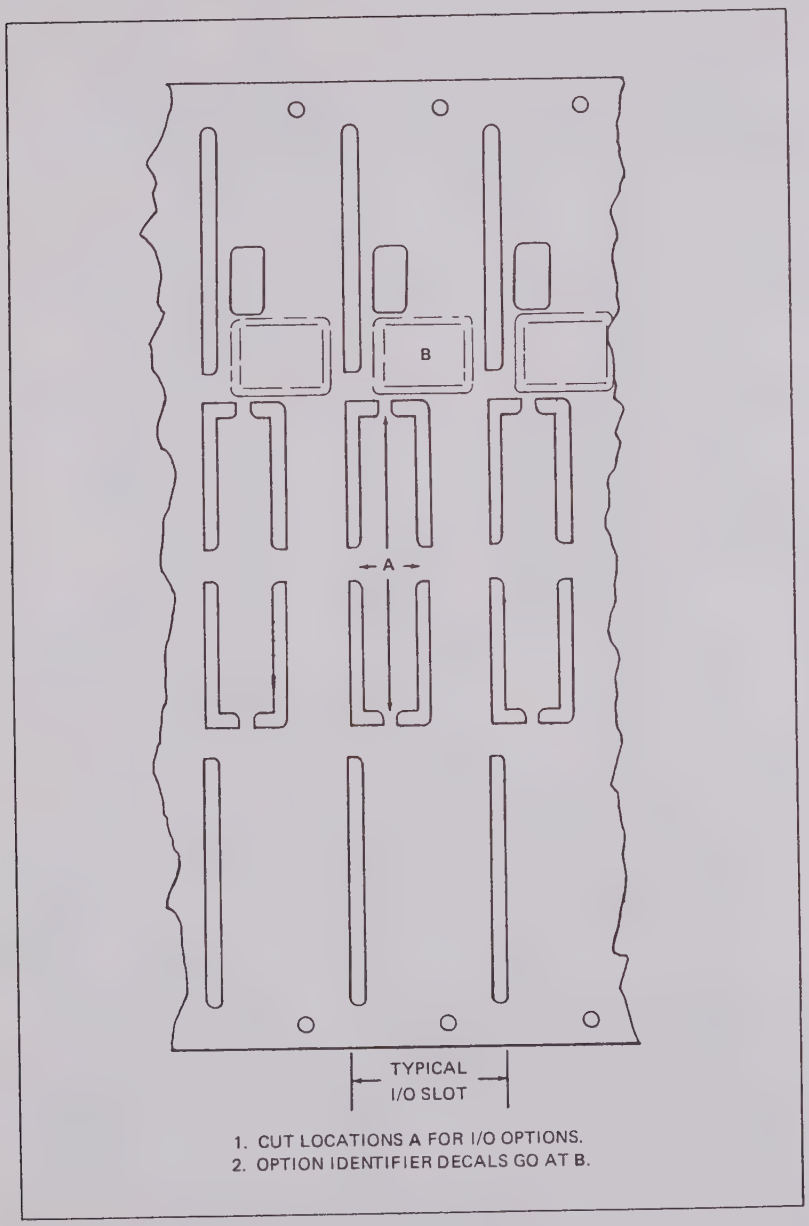


Figure 114-4. Rear Panel Detail

Table 114-4. Interrupt Input Connector Pin Assignments

PIN	SIGNAL	PIN	SIGNAL
1	Input 0	26	Input 13
2	Input 1	27	Input 14
3	Input 2	28	Input 15
4	Input 3	29	Not Connected
5	Input 4	30	Not Connected
6	Input 5	31	Not Connected
7	Input 6	32	Not Connected
8	Input 7	33	Not Connected
9	Isolated Common	34	Not Connected
10	Isolated Common	35	Not Connected
11	Isolated Common	36	Not Connected
12	Isolated Common	37	Not Connected
13	Isolated Common	38	Not Connected
14	Isolated Common	39	Isolated Common
15	Isolated Common	40	Isolated Common
16	Isolated Common	41	Not Connected
17	Isolated Common	42	Not Connected
18	Isolated Common	43	Not Connected
19	Isolated Common	44	Not Connected
20	Isolated Common	45	Not Connected
21	Input 8	46	Not Connected
22	Input 9	47	Not Connected
23	Input 10	48	Not Connected
24	Input 11	49	Isolated Common
25	Input 12	50	Isolated Common

Installation Verification Test

Two test procedures can be used to verify correct installation and operation of the Interrupt Input Assembly. If a Status Output assembly (Option 2400A-301) is available, use Method 1; Otherwise, use Method 2.

METHOD 1

If a Status Output Assembly is available, use the following procedure. Three test leads are needed for this test.

1. Install a Status Output Assembly in an I/O option slot in the 2400B. Install either the Screw Terminal Connector (2400A-110), or Solder Pin Connector (2400A-111) to the output mating connector of the Status Output Assembly. Using a test lead, connect pins 11 and 12 together.

2. Install a connector to the input mating connector of the Interrupt Input Assembly under test. Connect Isolated Common (pin 50) of the Interrupt Input Assembly to Isolated Common (pin 50) of the Status Output Assembly. Connect the Interrupt Input channel to be tested to its corresponding Status Output channel.

3. Apply power to the 2400B by depressing the POWER switch on the front panel.

4. Address the 2400B through the host device, and enter the following command:

```
SEND ILI(channel #)!
```

   Where "channel #" is the channel number assigned to the Interrupt Input under test.

5. Verify that the value returned by the 2400B is 0.

6. Enter the commands:

```
SO(channel #) = 1!
SEND ILI(channel #)!
```

7. Verify that the value returned is 1.

8. Enter the commands:

```
SO(channel #) = 0!
SEND ILI(channel #)!
```

9. Verify that the value returned is 0.

This completes installation verification Method 1.

METHOD 2

If a Status Output Assembly is not available, use the following procedure. One test lead is needed for this test.

1. Install either a Screw Terminal or Solder Pin connector to the input mating connector in the back of the Interrupt Input Assembly.

2. Apply power to the 2400B by depressing the POWER switch on the front panel.

3. Addressing the 2400B through the host device, enter the following command:

```
SEND ILI(channel #) !
```

   Where "channel #" is the channel number assigned to the Interrupt Input channel to be tested.

4. Verify that the value returned by the 2400B is 1.

5. Connect a test lead from the pin of the channel under test to Isolated Common (pin-50) on the connector. Enter the command:

```
SEND ILI(channel #) !
```

6. Verify that the value returned is 0.

This completes installation verification Method 2.

Service Information

Calibration procedures, troubleshooting procedures, parts lists, schematics, and theory of operation are presented in the 2400B Service Manual.

SECTION 9

OUTPUT OPTIONS

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Option 2400A-102 Thermocouple Input Connector 102-1
Option 2400A-106 Current Input Connector 106-1
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Option 2400A-109 High Performance A/D Converter 109-1
Option 2400A-115 Four-Wire Scanner 115-1
Option 2400A-116 Four-Wire Input Connector 116-1
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Option 2400A-306 Resistance Output (25 Ohms to 100 Kilohms) ... 306-1
Option 2400A-307 Stepper Motor Controller 307-1

OPTION 2400A-110 SCREW TERMINAL CONNECTOR

Description

The Screw Terminal Connector is a general purpose connector assembly that attaches to several of the input/output (I/O) option assemblies. The connector mates with the 50-pin, subminiature, type-D connector on each option assembly, allowing easy wiring to external devices. Wiring connections are made using five 10-contact screw-terminal strips. The 50 contacts listed in Table 110-1 are numbered to correspond exactly to the pin-out of the D-connector. Contact voltages must be limited to less than 30 volts from earth ground for safety. Table 110-2 gives specifications for the Screw Terminal Connector.

Table 110-1. Screw Terminal Connector Pin Assignments

D CONNECTOR PIN	SOLDER PIN NUMBER	D CONNECTOR PIN	SOLDER PIN NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

Table 110-2. Screw Terminal Connector Specifications

Connector Type	General Purpose Input/Output
Compatibility	Mates with the following option assemblies: -103 Status Input -104 Digital Input -104/AA Sequence of Events Recorder -114 Interrupt Input -301 Status Output -302 Current/Voltage Analog Output
Number of Terminals	50 per assembly
Terminal Style	Screw type
Maximum Voltage	30 volts between any terminal and/or ground
Weight	0.2 kg. (0.5 lb.)
Environmental	Meets all the environmental specifications of the 2400B

Installation

The Screw Terminal Connector mates with any of the I/O option assemblies listed in Table 110-2. Install the connector as follows:

1. Set chassis POWER switch to OFF.
2. Locate the desired I/O option D-connector on the rear panel and check that the I/O option pcb is properly installed. Check the type of option and its card number.
3. Referring to Figure 110-1 and Table 110-1, attach external wiring to the Screw Terminal Connector as required for your application.
4. Insert the connector assembly into the mating D-connector.
5. Secure the connector to the I/O option circuit board using the strain relief screws provided.
6. Repeat the procedure for any additional I/O connectors.

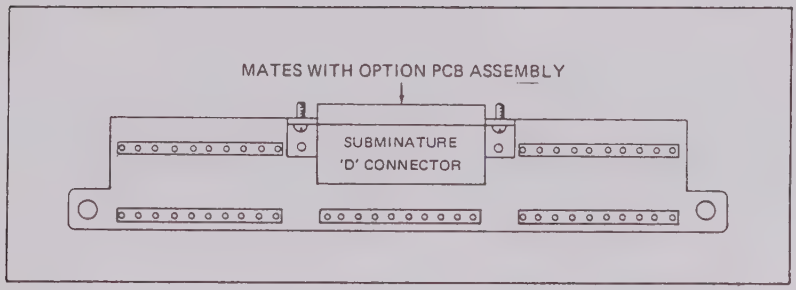


Figure 110-1. I/O Screw Terminal Connector

Operation

Once installed, the Screw Terminal I/O Connector is ready for use. No special operation steps are required.

Installation Verification and Performance Test

The most efficient way to verify correct installation of the I/O Connector, is to run through the verification test for the Input/Output assembly to which it is attached. Refer to the section of this guide describing the installation verification of the applicable I/O option.

Service Information

All applicable service information is provided in the 2400B Service Manual.

OPTION 2400A-111 SOLDER PIN CONNECTOR

Description

The Solder Pin Connector is a general purpose connector with a backshield. It is compatible with several of the input/output (I/O) option assemblies. The connector mates with the 50-pin, subminiature, type-D connector on each option assembly and provides solder terminals for wiring to external devices. The connections listed in Table 111-1 correspond exactly to the pin-out of the option connector. Contact voltages must be limited to 30 volts from earth ground. Specifications for the Solder Pin Connector are given in Table 111-2.

Table 111-1. Solder Pin Connector Pin Assignments

D CONNECTOR PIN	SOLDER PIN NUMBER	D CONNECTOR PIN	SOLDER PIN NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

Table 111-2. Solder Pin Connector Specifications

Connector Type	General Purpose Input/Output
Compatibility	Mates with the following option assemblies: -103 Status Input -104 Digital Input -104/AA Sequence of Events Recorder -114 Interrupt Input -301 Status Output -302 Current/Voltage Analog Output
Number of Terminals	50 per assembly
Terminal Style	Solder Pin
Maximum Voltage	30 volts between any terminal and/or ground
Weight	0.2 kg. (0.5 lb.)

Installation

The Solder Pin Connector mates with any of the I/O options listed in Table 111-2. Install the Solder Pin Connector as follows:

1. Set chassis POWER switch to OFF.

2. Locate the desired option I/O D-connector at the rear of the chassis and make sure the I/O option pcb is properly installed. Check the type of option and its card number.

3. Slip the connector backshield over the cable or wiring to be attached to the connector. Solder the wires to the Solder Pin Connector as required for the application.

4. Install the backshield on the connector.

5. Insert the connector assembly into the mating D-connector.

6. Secure the connector to the I/O option circuit board using the strain relief screws provided.

7. Repeat the procedure for any additional I/O connectors.

Operation

Once installed, the Solder Pin Connector is ready for use. No special operation steps are required.

Installation Verification and Performance Test

The most efficient way to verify correct installation of the Solder Pin Connector is to run through the installation verification test for the Input/Output assembly it is attached to. Refer to the section in this guide describing the installation verification test for the applicable I/O option.

Service Information

All applicable service information is included in the 2400B Service Manual.

OPTION 2400A-301 STATUS OUTPUT

Description

The Status Output (Option 2400A-301) is a plug-in printed circuit board (pcb) assembly that sends 32 single-bit output signals to external control points or terminals. Each output is individually selectable and can turn devices such as lamps and relays on and off, or change logic levels. The Status Output is totally solid state, using Darlington transistor switching circuits for outputs (see Figure 301-1).

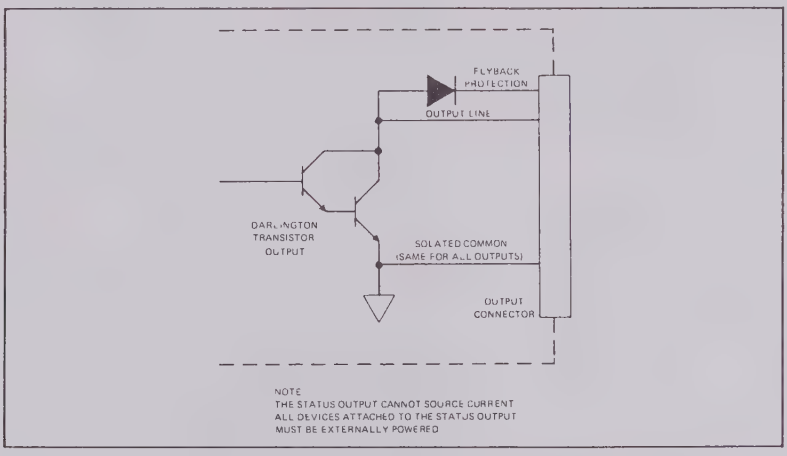


Figure 301-1. Equivalent Circuit For Each Status Output Channel

The Status Output option is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. By using 2402A I/O Extender Chassis, up to 32 assemblies (1024 outputs) may be installed per system.

The Status Output Option assembly mounts in any I/O option slot in the 2400B or 2402A chassis. Output data is routed through a 50-pin, subminiature, D-type connector, to the Screw Terminal Connector (Option 2400A-110), or Solder Pin Connector (Option 2400A-111). Either connector provides the electrical connection for output signals. Table 301-1 gives the specifications of the Status Output assembly.

Installation

The Status Output assembly mounts in any of the available I/O option slots in the 2400B or 2402A chassis (see Figure 301-2). Use the following procedure to install the Status Output assembly:

1. Set the chassis POWER switch to OFF.

Table 301-1. Status Output Specifications

Number of Outputs	32 individually selectable output bits per assembly.
Maximum Number of Outputs Per System	1024 (32 per assembly, 32 assemblies per system).
Output Isolation	Outputs are isolated in common from the 240C up to 30 volts and 1 volt/microsecond maximum slew rate.
Output Circuitry	Open collector darlington transistor outputs. Each output is flyback diode protected for use with relays (see Figure 301-1 and 301-2).
Maximum Sink Current	100 mA
Output Voltage	1.1 Volt at maximum sink current.
TTL Compatibility	Each output may drive one pulled-up standard TTL load, or three pulled-up Low-power Schottky loads. Pull-up resistor should be 50K ohms minimum.
Maximum OFF-state Voltage	50 Volts dc.
Maximum OFF-state Leakage Current	100 μA at 70 degrees Celsius ambient temperature and 50 V dc output voltage.
Output Logic	Under normal operation, setting output to '1" turns output ON (logic low). Outputs are initialized "OFF" at Power-up. Output polarity may be inverted by tying pin -11 (Output polarity select) of the output connector to pin 12 (Isolated Common) or a low logic level. Do not tie pin 12 to a status output on the same card; the circuit created will function as an oscillator.
Power Consumption	12 watts per pcb added to the system.
Weight	0.45 kb (1 lb)
Environmental	Meets all the environmental specifications of the 2400

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Remove the rear panel from the chassis.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. To select the best I/O option slot for mounting the Status Output assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the pcb in its selected I/O option slot so that the large offset card-edge connector is toward the front of the chassis, and the subminiature, D-type connector is toward the rear of the unit. Push the pcb straight back into the chassis until it seats in the mating connector.

6. If installing more than one Status Output, locate the Card Select Switches on each assembly (see Figure 301-3) and assign consecutive card numbers (starting with 0) to each pcb. Table 301-2 shows card number switch patterns. Card numbers determine which output channels are assigned to each pcb. (Card 0 provides outputs 0 through 31, Card 1 provides outputs 32 through 63, and so on.)

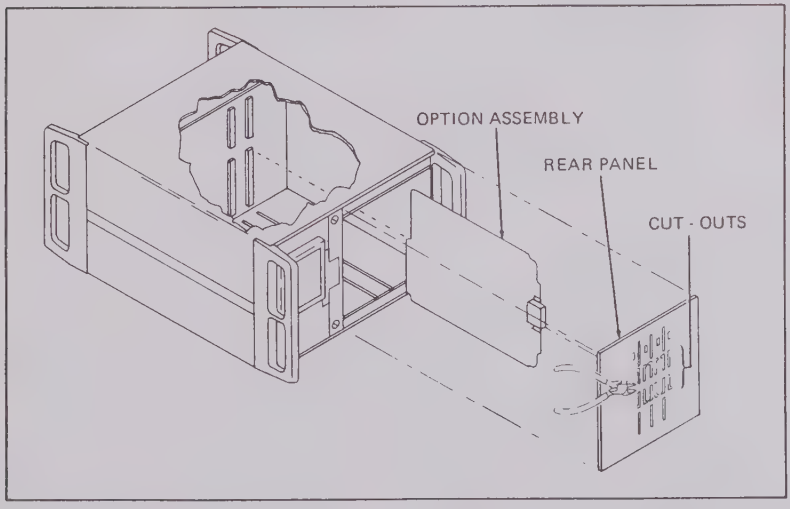


Figure 301-2. I/O Option Slots

7. After Status Output installation, replace the rear panel, removing the rear panel connector cutout(s) as necessary.

8. Attach the option identification decal(s) to the rear panel (see Figure 301-4).

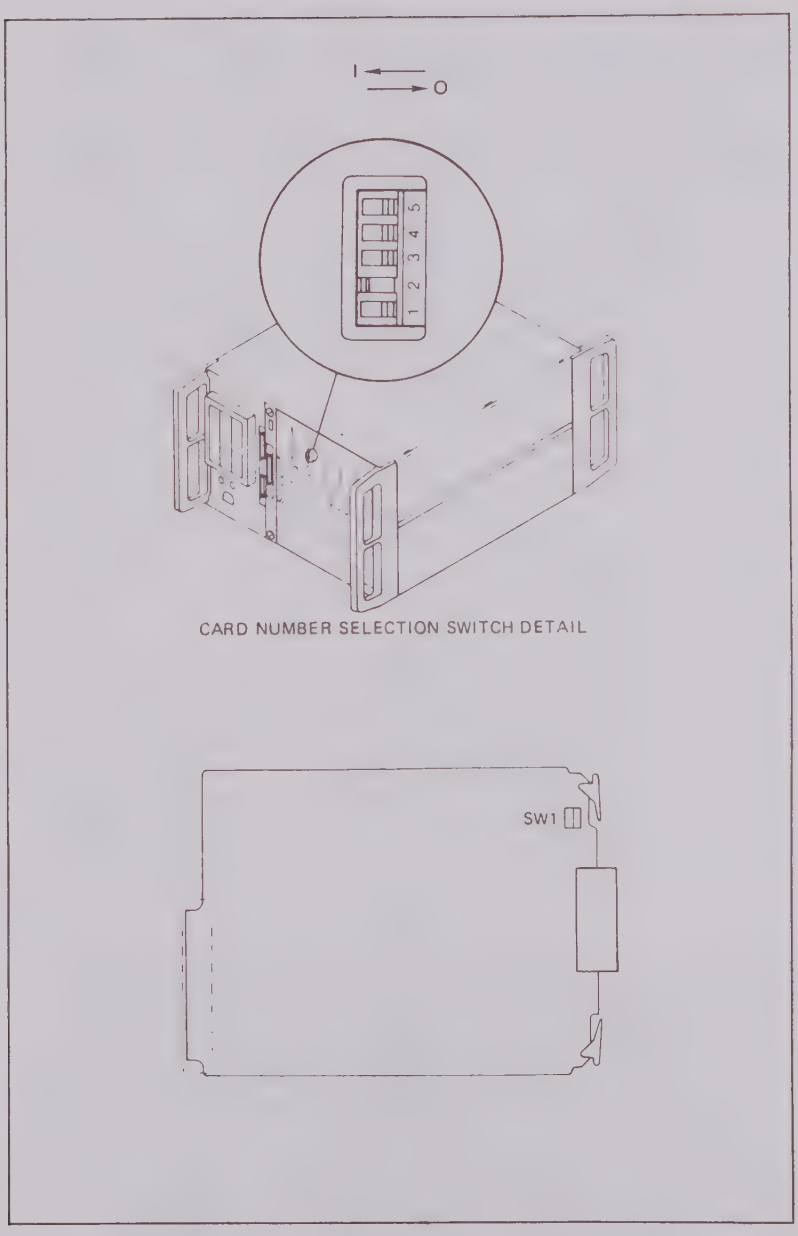


Figure 301-3. Card Select Switch Location

Table 301-2. Status Output Card Select Switch Settings

LEFT = ONE, RIGHT = ZERO S1 SWITCH SETTINGS = X X X X X						
Card Number	Switch Segments					Status Output Channels Assigned
	B5	B4	B3	B2	B1	
0	0	0	0	0	0	0-31
1	0	0	0	0	1	32-63
2	0	0	0	1	0	64-95
3	0	0	0	1	1	96-127
4	0	0	1	0	0	128-159
5	0	0	1	0	1	160-191
6	0	0	1	1	0	192-223
7	0	0	1	1	1	224-255
8	0	1	0	0	0	256-287
9	0	1	0	0	1	288-319
10	0	1	0	1	0	320-351
11	0	1	0	1	1	352-383
12	0	1	1	0	0	384-415
13	0	1	1	0	1	416-447
14	0	1	1	1	0	448-479
15	0	1	1	1	1	480-511
16	1	0	0	0	0	512-543
17	1	0	0	0	1	544-575
18	1	0	0	1	0	576-607
19	1	0	0	1	1	608-639
20	1	0	1	0	0	640-671
21	1	0	1	0	1	672-703
22	1	0	1	1	0	704-735
23	1	0	1	1	1	736-767
24	1	1	0	0	0	768-799
25	1	1	0	0	1	800-831
26	1	1	0	1	0	832-863
27	1	1	0	1	1	864-895
28	1	1	1	0	0	896-927
29	1	1	1	0	1	928-959
30	1	1	1	1	0	960-991
31	1	1	1	1	1	992-1023

Operation

Once installed in the chassis, the Status Output option is ready for use and requires no operator attention. Complete the external connections from the output connector to the device to be controlled using the Screw Terminal Connector (Option 2400A-110), or the Solder-Pin Connector (Option 2400A-111). Table 301-3 lists the pin assignments for these two connectors.

OPERATING COMMANDS

Refer to the 2400B command set to make full use of the Status Output assembly's features. The 2400B Programming Guide provides detailed status output control function information, and an explanation of the commands used.

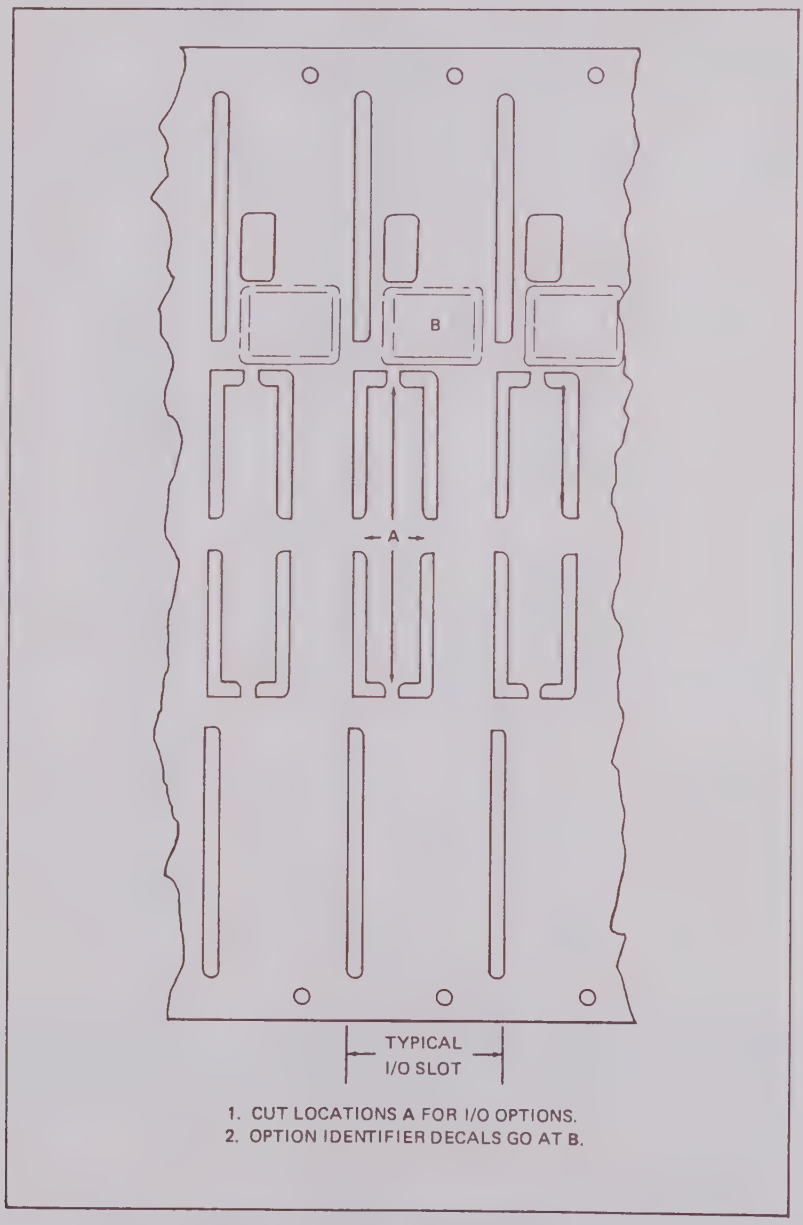


Figure 301-4. Rear Panel Detail

FLYBACK DIODE PROTECTION

When using the Status Output assembly to drive relays, it is important to protect the outputs with diodes to prevent damage caused by inductive kick (flyback) when the outputs are turned off. The 32 outputs on each assembly may be protected, in groups of eight, by connecting the proper pin on the output connector (see Table 301-3 and Figure 301-5) to the coil voltage of the relays being driven. If you need to drive relays with different coil voltages with a single group of eight outputs, flyback protection must be achieved using external discrete components.

Installation Verification Test

To verify proper installation of the assembly, several approaches may be used, depending on equipment available. These approaches are listed in order of preference. Refer to the 2400B Programming Guide for a detailed explanation of the commands used below:

Table 301-3. Status Output Connector Pin Assignments

PIN	SIGNAL	PIN	SIGNAL
1	Output 0	26	Output 13
2	Output 1	27	Output 14
3	Output 2	28	Output 15
4	Output 3	29	Flyback Protection Outputs 8-15
5	Output 4	30	Isolated Common
6	Output 5	31	Output 16
7	Output 6	32	Output 17
8	Output 7	33	Output 18
9	Flyback Protection Outputs, 0-7.	34	Output 19
10	Isolated Common	35	Output 20
11	Polarity Select	36	Output 21
12	Isolated Common	37	Output 22
13	Isolated Common	38	Output 23
14	Isolated Common	39	Flyback Protection Outputs 16-23
15	Isolated Common	40	Isolated Common
16	Isolated Common	41	Output 24
17	Isolated Common	42	Output 25
18	Isolated Common	43	Output 26
19	Isolated Common	44	Output 27
20	Isolated Common	45	Output 28
21	Output 8	46	Output 29
22	Output 9	47	Output 30
23	Output 10	48	Output 31
24	Output 11	49	Flyback Protection Outputs 24-31
25	Output 12	50	Isolated Common

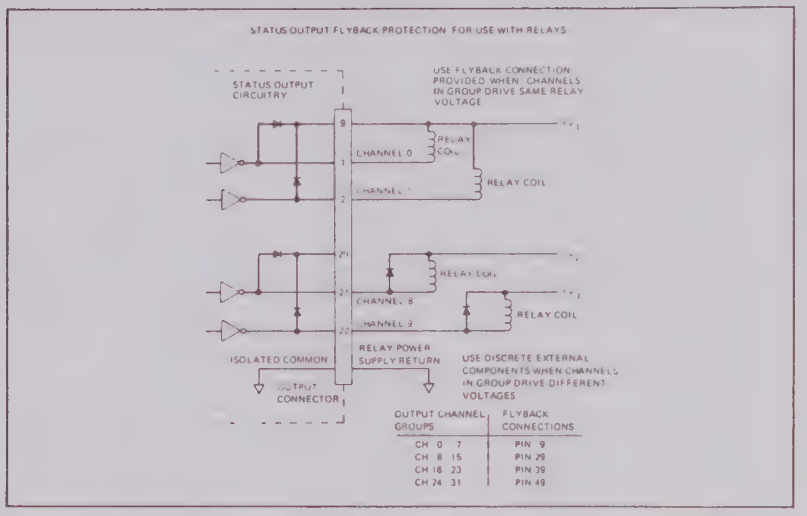


Figure 301-5. Status Output Flyback Protection

METHOD 1

This method should be used if a Status Input Assembly (Option 2400A-104) is installed. You will also need three test leads and a host device to address the 2400B.

1. With the 2400B power off, make sure the Status Input and Status Output assemblies are properly installed, with connectors attached, in the chassis.

2. Connect pins 11 and 12 on the Status Output under test with one of the test leads.

3. Connect pin 50 (Isolated Common) of the Status Input connector to pin 50 (Isolated Common) of the Status Output Connector with another test lead.

4. Connect a Status Output channel to the corresponding Status Input channel with the third test lead.

5. Depress the POWER switch on the 2400B front panel.

6. Addressing the 2400B through the host device, enter the following command:

```
SEND SI(channel #) !
```

Where "channel #" is the channel number of the Status Input being used.

7. Verify that the value sent by the 2400B is a logical 0.

8. Enter the commands:

```
SO(channel #) =1!
SEND SI(channel #) !
```

9. Verify that the value sent is a logical 1.

10. Enter the command:

```
SO(channel #) =0!
SEND SI(channel #) !
```

11. Verify that the value sent is a logical 0.

This completes the installation verification test using the first method. If a Status Input assembly is not available, the following method may be used.

METHOD 2

You will need a digital multimeter (DMM), such as the Fluke 8020A, the Fluke 70 Series, or equivalent to use this method.

1. Set the DMM to read ohms in a range in which the DMM supplies enough voltage to turn on a PN junction (2 kilohm range on the 8020A, use the special diode test function with a 70 Series DMM). If your meter has a diode checking range, use that range setting.

2. With the 2400B power OFF, Connect the positive (V/kOHMS) input lead of the DMM to a Status Output channel terminal. Connect the COMMON input lead of the DMM to pin 50 (Isolated Common) on the Status Output connector.

3. Depress the POWER switch on the 2400B front panel.

4. Addressing the 2400B through the host device, enter the following command:

```
SO(channel #) =1!
```

Where "channel #" is the channel number of the status output under test.

5. Verify that the DMM reads approximately 1 kilohm (70 Series DMM should read approximately 0.7 volts).

6. Enter the command:

SO(channel #) =0!

7. Verify that the reading is now overrange.

This completes the second method for Status Output verification.

METHOD 3

This verification test method of the Status Output assembly is to connect externally powered circuitry to be controlled by the output. Such circuitry might consist of a light-emitting diode (LED) connected to the open collector output with a current-limiting resistor, as necessary. The exact nature of this circuitry is at your discretion.

1. After connecting the test circuit, apply power to it. Turn on the 2400B power, and verify that the test circuit is off.

2. Addressing the 2400B through the host device, enter the following command:

SO(channel #) =1!

Where "channel #" is the channel number of the status output under test.

3. Verify that the test circuit has turned on.

3. Enter the command:

SO(channel #) =0!

4. Verify that the test circuit has turned off.

This completes the third method for Status Output installation verification.

Service Information

All applicable service information is included in the 2400B Service Manual.

OPTION 2400A-302 CURRENT/VOLTAGE ANALOG OUTPUT

Description

The Current/Voltage Analog Output assembly allows the 2400B to send analog control signals to external control points or other external devices. It has four fully isolated output channels per assembly. The channels are configured with jumpers to output either voltage or current.

The Current/Voltage Analog Output assembly is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. Each 2400B chassis can accept up to six Analog Output assemblies. By using 2402A I/O Extender Chassis, up to 32 assemblies (128 outputs) may be installed per system.

The outputs are accessible through a 50-pin subminiature D-type connector mounted at the rear of each assembly. Each channel has a four-wire connection to the load from the voltage outputs to eliminate errors introduced by wire resistance. Complete specifications for the Voltage/Current Analog Output assembly are given in Table 302-1.

Table 302-1. Current/Voltage Analog Output Specifications

Number of Outputs per Assembly ...	Four fully isolated outputs
Maximum Number of Outputs per System	128 (32 assemblies maximum per extended system).
Output Configurations	Current (0 to 20 mA)
Voltage Configuration	Voltage (-10 to +10V dc)
ACCURACY (90 DAYS)	±0.1% of Full Scale (90 days, 18 to 28°C). Remote sense capability can be used to insure accuracy at the load.
DYNAMIC RANGE	8000 counts (±4000 counts)
RESOLUTION	2.5 mV per count
OVERRANGE	2.375% of full scale
MAX OUTPUT CURRENT	±5 mA
MAX NON-LINEARITY	0.012% of full scale (included in the accuracy statement).

Table 302-1. Current/Voltage Analog Output Specifications (cont.)

MONOTONICITY	monotonic over full range
TEMPERATURE STABILITY	50 ppm/Degree Celsius (included in the accuracy statement).
CAPACITIVE LOAD	Will drive up to 10,000 pf without instability.
OUTPUT PROTECTION	All outputs are short circuit protected.
Current Configuration (Obtained after moving two jumpers).	
ACCURACY	90 days, 18 to 28°C Celsius
Before Recalibration	±2% of full scale
After Recalibraiton (90 days, 18°C to 28°C)	±0.1% of full scale
DYNAMIC RANGE	4000 counts
RESOLUTION	5 uA per count
OVERRANGE	2.375% of full scale
MAX EXTERNAL VOLTAGE	±24V
COMPLIANCE VOLTAGE	15V
MAX NON-LINEARITY	±0.25% of full scale (included in accuracy statement).
TEMPERATURE STABILITY	60 ppm/Degree Celsius (included in the accuracy statement).
Output Isolation	All outputs are isolated from the chassis and each other up to 30V and a maximum dv/dt of 1.0V/microsecond.
System Power Consumption	12 watts per assembly added to the system.
Weight	0.9 kg. (2 lb.)
Environmental Specifications	Meets all the environmental specifications of the 2400

Installation Notes

Before installing the Current/Voltage Analog Output assembly, check the configurations of each output to ensure proper operation for the type of external device to be controlled. When shipped from the factory, all four channels of the Current/Voltage Analog Output assembly are configured and calibrated as voltage outputs. By moving two jumpers and recalibrating, the user may convert any channel into a current output. Refer to the 2400B Service Manual for this procedure.

To determine the configuration of each channel, examine the assembly. Looking at the component side of the printed circuit board, locate the jumpers shown in Figure 302-1. Compare the jumper locations to the detailed sections of Figure 302-1 to identify channel configuration.

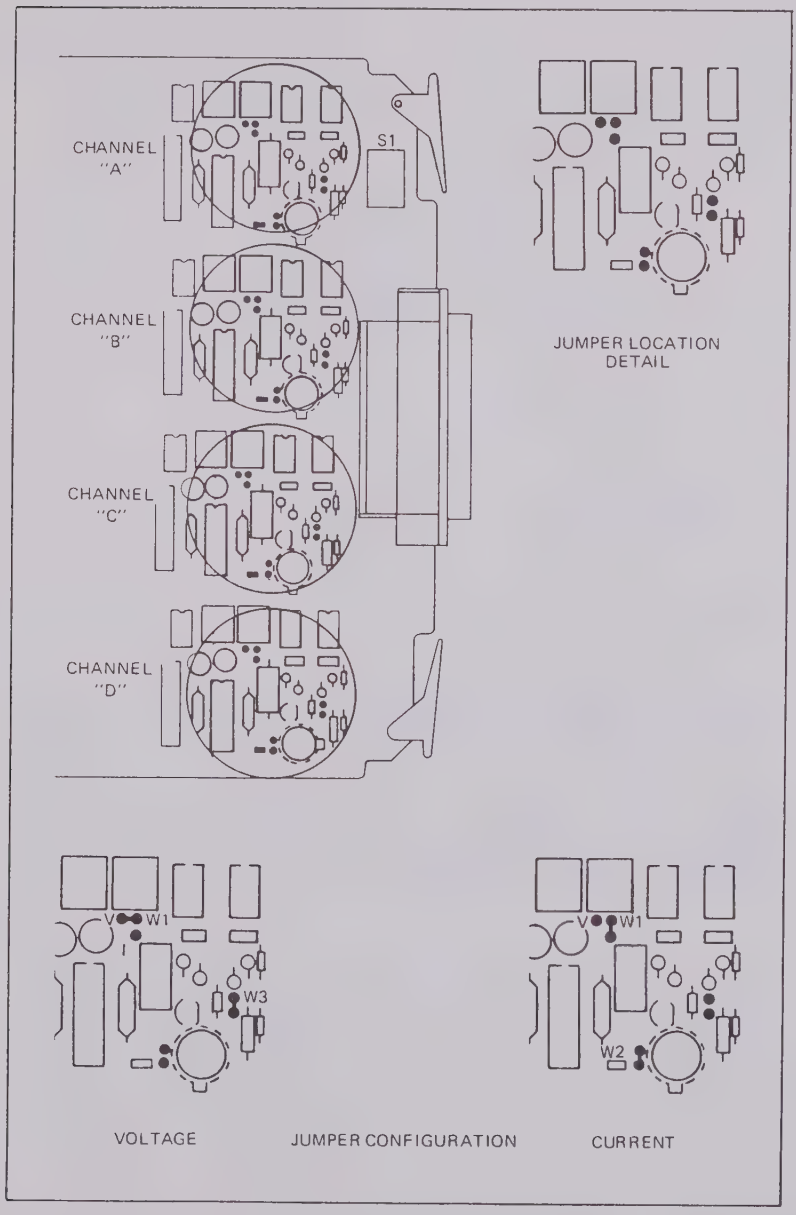


Figure 302-1. Output Jumper Locations

Installation

The Current/Voltage Analog Output assembly mounts in any of the available I/O option slots in the 2400B or 2402A chassis (see Figure 302-2). Use the following procedure to install the Current/Voltage Analog Output assembly:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER CONNECTION AND ALL OTHER HIGH VOLTAGE INPUTS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

3. Remove the rear panel from the chassis.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

4. To select the best I/O option slot for mounting the output assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

5. Align the pcb in the selected I/O option slot so that the large offset card-edge connector is toward the front of the chassis, and the subminiature, D-type connector is toward the rear of the unit. Push the pcb straight into the chassis mating connector.

6. Locate the Card Select Switch on the pcb (see Figure 302-3) and assign the pcb a card number (consecutively, starting with 0, for each pcb assembly) by setting the switches to the patterns shown in Table 302-2. The number selected will determine the output channels assigned to each pcb. Example: Card 0 provides outputs 0 through 3, Card 1 provides outputs 4 through 7, and so on.

7. After the Analog Output assembly is installed, replace the rear panel. Remove the rear panel connector cut-out(s) as necessary.

8. Attach the option identification decal(s) to the rear panel as Figure 302-4 shows.

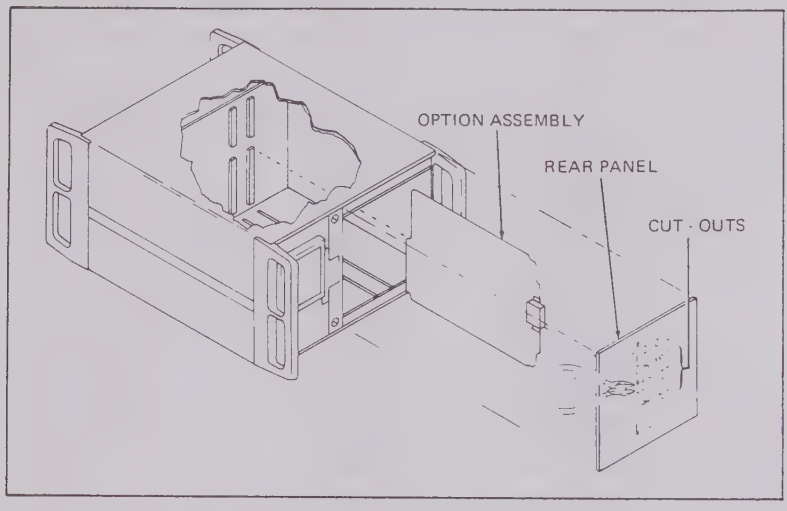


Figure 302-2. I/O Option Mounting Locations

Operation

Once installed in the chassis, the Current/Voltage Analog Output assembly is ready for use. Connect external wires from the output connector to the external points to be controlled. Option 2400A-110 Screw Terminal Connector and Option 2400A-11 Solder Pin Connector are used for this purpose.

Refer to the 2400B command set to make full use of the Current/Voltage Analog Output assembly. The 2400B Programming Guide has a description of the 2400B Analog Output control functions and a detailed explanation of the command set.

SENSE LINE CONNECTIONS

For maximum accuracy in voltage applications requiring long output wiring, where resistance between output and load may be of concern, the voltage sense lines should be used. By connecting the positive and negative voltage output lines to the corresponding sense lines at the load, the Analog Output circuitry is allowed to adjust the output voltage to maintain the desired voltage level at the load. This procedure applies only to voltage outputs.

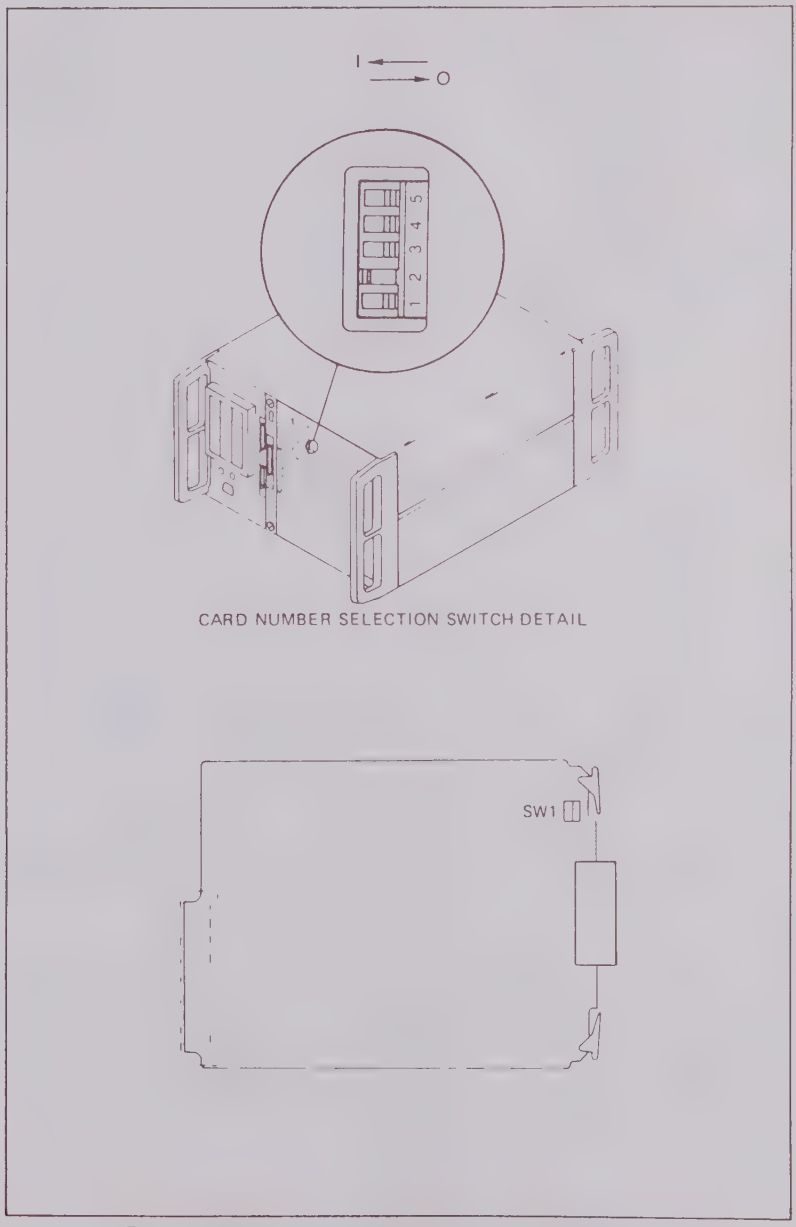


Figure 302-3. Card Select Switch Location

Table 302-2. Current/Voltage Analog Output Switch Settings

S1 SWITCH SETTING = X X X X X LEFT = ONE, RIGHT = ZERO									
Card Number	Switch Segments					Analog Output channels (A, B, C, D) assigned:			
	B5	B4	B3	B2	B1	A	B	C	D
0	0	0	0	0	0	0	1	2	3
1	0	0	0	0	1	4	5	6	7
2	0	0	0	1	0	8	9	10	11
3	0	0	0	1	1	12	13	14	15
4	0	0	1	0	0	16	17	18	19
5	0	0	1	0	1	20	21	22	23
6	0	0	1	1	0	24	25	26	27
7	0	0	1	1	1	28	29	30	31
8	0	1	0	0	0	32	33	34	35
9	0	1	0	0	1	36	37	38	39
10	0	1	0	1	0	40	41	42	43
11	0	1	0	1	1	44	45	46	47
12	0	1	1	0	0	48	49	50	51
13	0	1	1	0	1	52	53	54	55
14	0	1	1	1	0	56	57	58	59
15	0	1	1	1	1	60	61	62	63
16	1	0	0	0	0	64	65	66	67
17	1	0	0	0	1	68	69	70	71
18	1	0	0	1	0	72	73	74	75
19	1	0	0	1	1	76	77	78	79
20	1	0	1	0	0	80	81	82	83
21	1	0	1	0	1	84	85	86	87
22	1	0	1	1	0	88	89	90	91
23	1	0	1	1	1	92	93	94	95
24	1	1	0	0	0	96	97	98	99
25	1	1	0	0	1	100	101	102	103
26	1	1	0	1	0	104	105	106	107
27	1	1	0	1	1	108	109	110	111
28	1	1	1	0	0	112	113	114	115
29	1	1	1	0	1	116	117	118	119
30	1	1	1	1	0	120	121	122	123
31	1	1	1	1	1	124	125	126	127

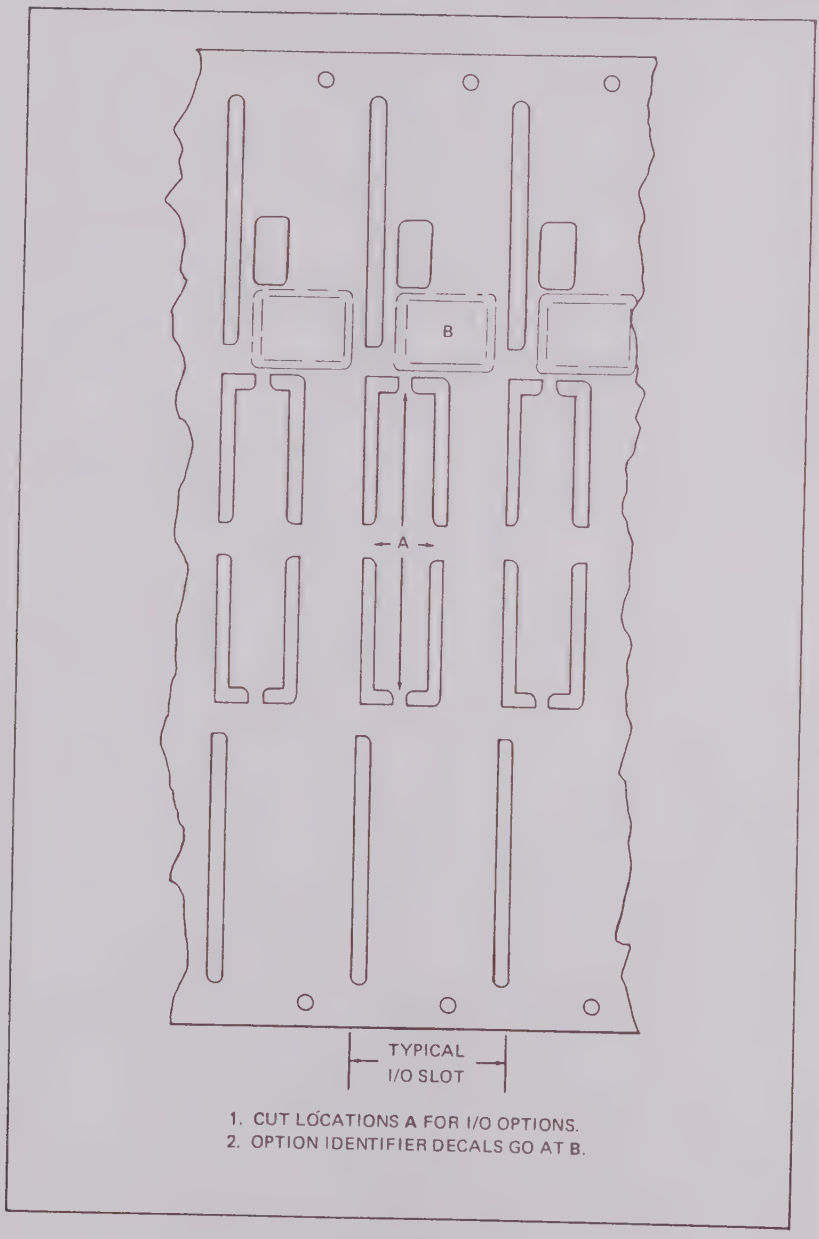


Figure 302-4. Rear Panel Detail

OUTPUT RANGE DOUBLING

Since all output channels are isolated from each other, it is possible to obtain higher output values from the voltage outputs by connecting them in series. As an example, consider connecting channels A and B in series to the load. If POS output of B is connected to the NEG output of A, then the remaining two output lines will provide double the normal output range. Connecting the sense lines proceeds as described for a single output, except that the POS sense line for channel B must be connected to the NEG sense line for channel A (see Figure 302-5.) Current outputs may also be linked together. By connecting two current outputs in parallel (see the lower half of Figure 302-5), the output current range may be doubled.

Installation Verification Test

To verify proper installation of the Current/Voltage Analog Output assembly, the following procedure can be used. Refer to the 2400B Programming Guide for an explanation of the commands used below.

For the test you will need a digital multimeter (DMM), such as the Fluke 8020A, the Fluke 70 Series, or equivalent. The Current/Voltage Analog Output assembly must be equipped with either the Screw Terminal Connector (Option 2400A-110) or Solder Pin Connector (Option 2400A-111). Table 302-3 gives the Current/Voltage Output assembly output connector pin assignments.

The channels of the Current/Voltage Analog Output assembly can be individually configured to source either voltage or current. Look under the heading, Installation Notes to determine the output configuration of the channel(s) to be tested. Use the appropriate procedure for each channel.

Note

If the output configuration of a channel is changed (from voltage to current or current to voltage), the channel must be recalibrated to obtain accuracy better than +/- 2%.

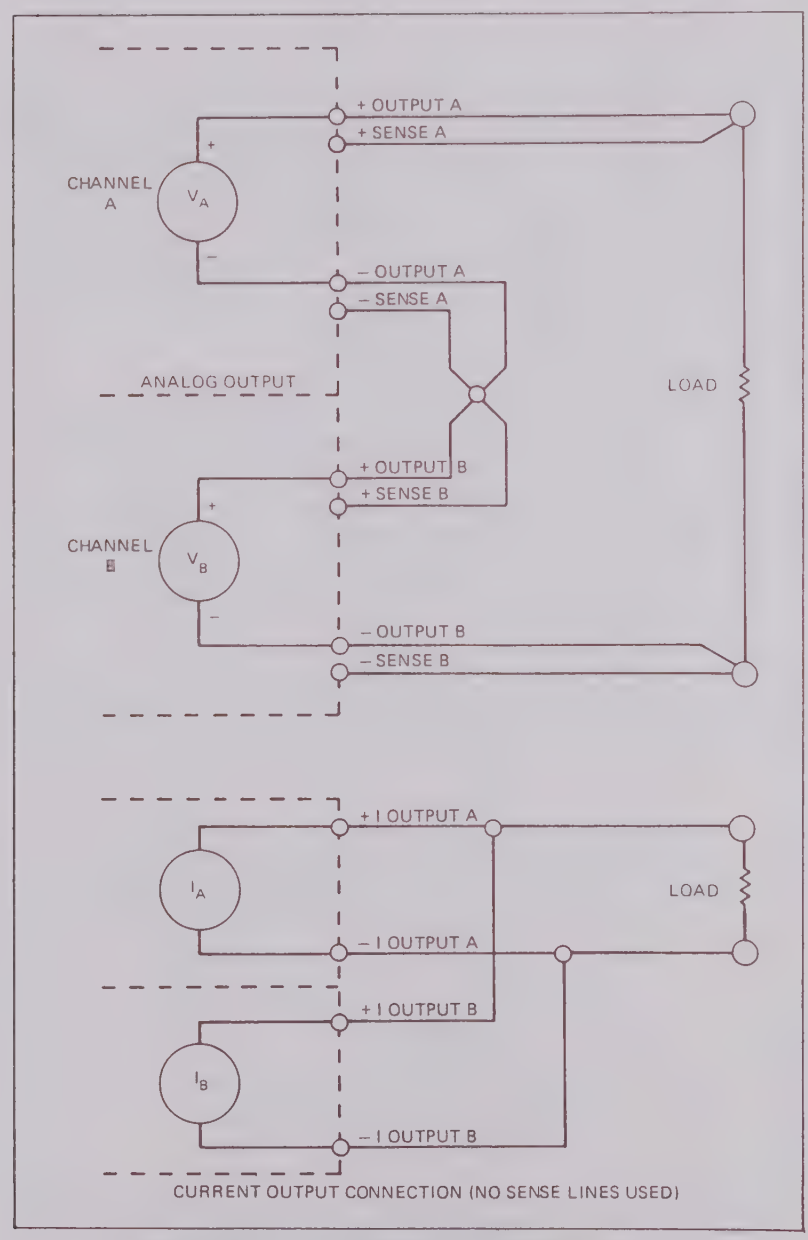


Figure 302-5. Output Sense Line Connections

VOLTAGE OUTPUT

1. Connect either the Screw Terminal (2400A-110) or Solder Pin (2400A-111) Connector to the output connector of the Analog Output assembly.

2. Connect the positive (V/kOHMS) input lead of the DMM to +Voltage Output of the channel under test. Connect the COMMON input lead of the DMM to -VOLTAGE output of the channel under test.

3. Set the DMM to read DC volts on the 20 volt range.

4. Apply power to the 2400B by depressing the POWER switch on the front panel. The display on the DMM should read 0 volts.

Table 302-3. Voltage/Current Analog Output Connector Pin Assignments

PIN	SIGNAL	PIN	SIGNAL
50	+ Voltage Output A	22	- Current Output C
49	- Voltage Output A	40	Test Point 26C
32	+ Voltage Sense A	41	Test Point 26C
31	- Voltage Sense A	6	Test Point 27C
17	+ Current Output A	9	Not Used
16	- Current Output A	1	+ Voltage Output D
47	Test Point 26A	2	- Voltage Output D
48	Test Point 26A	19	+Voltage Sense D
33	Test Point 27A	18	- Voltage Sense D
3	Not Used	35	+ Current Output D
12	+ Voltage Output B	20	- Current Output D
13	- Voltage Output B	36	Test Point 26D
28	+ Voltage Sense B	37	Test Point 26D
29	- Voltage Sense B	34	Test Point 27D
10	+ Current Output B	14	Not Used
27	- Current Output B	15	Not Used
44	Test Point 26B	21	Not Used

Table 302-3. Voltage/Current Analog Output Connector Pin Assignments (cont.)

45	Test Point 26B	25	Not Used
11	Test Point 27B	26	Not Used
4	Not Used	30	Not Used
7	+ Voltage Output C	38	Not Used
8	- Voltage Output C	39	Not Used
23	+ Voltage Sense C	42	Not Used
24	- Voltage Sense C	43	Not Used
5	+ Current Output C	46	Not Used

5. Address the 2400B through the host device and enter the following command:

   AO (channel #)=5 !

   Where "channel #" is the channel number of the output under test.

6. Verify that the DMM reads +5.0 volts.

7. Enter the command:

   AO (channel #) = -10 !

8. Verify that the DMM reads -10 volts.

9. This completes the voltage output installation verification test.

CURRENT OUTPUT

1. Connect the positive (mA) input lead of the DMM to the +CURRENT output of the channel under test. Connect the COMMON input lead of the DMM to -CURRENT output of the channel under test.

2. Set the DMM to read DC milliamperes input on the 20 milliampere range.

3. Apply power to the 2400B by depressing the POWER switch on the front panel. The display on the DMM should read 0 milliamperes.

4. Address the 2400B through the host device, and enter the following command:

   DEFN AOCHAN = <channel #>, TYPE = CURENT; !

   Where "channel #" is the channel number under test.

5. Enter the command:

   AO(channel #) = 50 !

6. Verify that the DMM reads +10 mA.

7. Enter the command:

   AO(channel #) = 90!

8. Verify that the DMM reads +18 mA.

This completes the Installation Verification Test.

Service Information

All applicable service information is included in the 2400B Service Manual.

OPTION 2400A-305 RESISTANCE OUTPUT (1 OHM TO 4 KILOHMS)

Introduction

The 2400A-305 Resistance Output option is a pcb assembly and output connector. It is used as a control interface for applications requiring a programmable resistance output. There are two variable resistive outputs on each pcb assembly. Each output is implemented with a 12-bit resistor ladder that is switched by reed relays to provide a two-terminal resistance from 0 to 4095 ohms in one-ohm increments. Specifications for the Resistance Output assembly are given in Table 305-1.

The pcb assembly mounts in any of the six I/O option slots in the back of the 2400B, or in any of the 12 I/O option slots in a 2402A chassis. By using 2402A I/O Extenders, a total of 32 Resistance Output assemblies (64 outputs) may be installed per system.

Table 305-1. 2400A-305 Resistance Output Specifications

Outputs per Assembly	2 variable resistive outputs (see Figure 305-1)
Maximum Number of Channels per System	64 (2 per assembly, maximum of 32 assemblies (either option -305 or -306) per extended system.
Range	0 to 4095 ohms
Resolution	1 ohm
Accuracy	±0.1% of full scale at output connector (as calibrated from the factory).
Calibration Interval	90 days at 18 to 28 degrees Celsius ambient temperature.
Temperature Coefficient	.005% of output/degree Celsius
Maximum Power Dissipation	1/8 watt per output
Output Isolation	Each output is electrically isolated up to 30 volts. 1.0 Volt/microsecond slew rate maximum.
Output Protection	Output is set to a value of 0 ohms whenever power is interrupted or for 2 to 4 milliseconds whenever the output value is being changed.
Power Consumption	12 watts per assembly added to the system.
Offset Resistance	Provision is made to allow user installation of an offset resistor on the Resistance Output PCB. This may be necessary for control applications requiring a non-zero output resistance at power down. For operation description, refer to the Operation Reference Section of this manual.
Weight	0.4 kg. (1 lb.)
Environmental Specifications	Meets all the environmental specifications for the 2400.

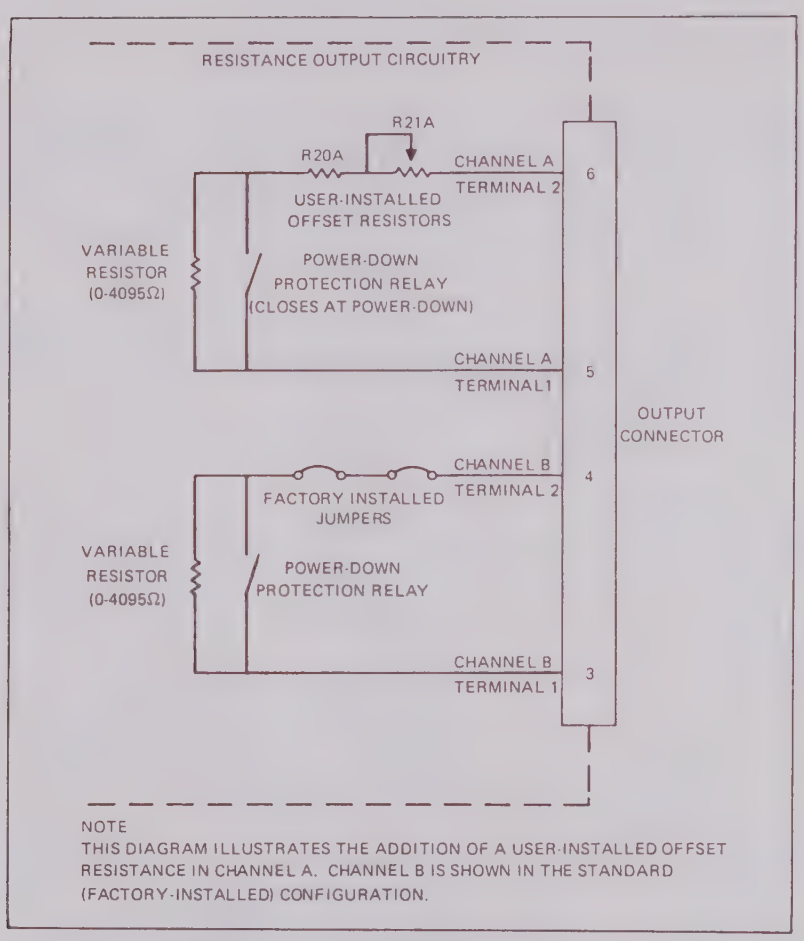


Figure 305-1. Equivalent Circuit of the Resistance Output

The output is accessible through the connector provided with the option. The connector has six screw terminals, with four used for the two outputs. Figure 305-1 gives an equivalent circuit for a Resistance Output channel.

Installation Notes

For applications requiring a non-zero minimum resistance output, an offest resistance may be added to the assembly by the user. To do this, a 1/8-watt metal film resistor or a 20-turn cermet potentiometer, or both of the devices, may be connected in series with the Resistance Output. The total resistance of these devices is called the offest resistance, and is added to the normal resistance of the Resistance Output.

To modify the low-numbered output (Channel A) of the Resistance Output assembly, follow the instructions in the next paragraph. The high-numbered output (Channel B) may be modified in the same way, by substituting Channel B components into the procedure. Examples: W1A becomes W1B; R20A becomes R20B.

To install a metal film resistor, locate and cut jumper W1A, then insert the resistor into the holes labeled R20A. To install a 20-turn cermet potentiometer, locate and cut jumper W2A, and insert the potentiometer terminals in the holes labeled R21A.

Installation

The Resistance Output assembly mounts in any of the available I/O option slots in the 2400B or 2402A chassis (see Figure 305-2). Use the following procedure to install the Resistance Output Assembly:

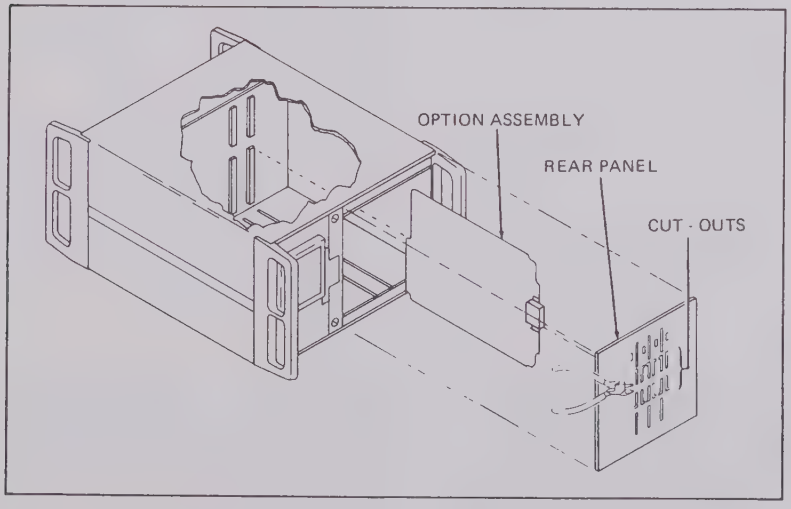


Figure 305-2. I/O Option Mounting Locations

WARNING

TO AVOID ELECTRIC SHOCK, REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS BEFORE CONTINUING.

1. Set the chassis POWER switch to OFF.

2. Remove the rear panel from the chassis.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

3. To select the best I/O option slot for mounting the 2400A-305 Resistance Output assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

4. Align each pcb in its selected I/O option slot so that the large card-edge connector is toward the front of the chassis, and the small card-edge connector is toward the back of the unit. Push the pcb into the chassis mating connector.

5. Locate the Card Select Switches on each pcb (see Figure 305-3) and assign consecutive card numbers (starting with 0) to each pcb by setting the switches to the patterns shown in Table 305-2. The number selected will determine the output channels assigned to each pcb. Example: Card 0 provides outputs 0 and 1, Card 1 provides outputs 2 and 3, and so on.

6. After the Resistance Output pcb is installed, replace the rear panel, removing the rear panel connector cutouts as necessary (see Figure 305-4).

7. Attach the option identification decal to the rear panel as Figure 305-4 shows.

8. Install the Output connector.

Operation

Once installed in the chassis, the Resistance Output assembly is ready for use. Complete the external connections for the screw-terminal output connector to the device to be controlled. The pin-assignments on the output connector are given in Table 305-3.

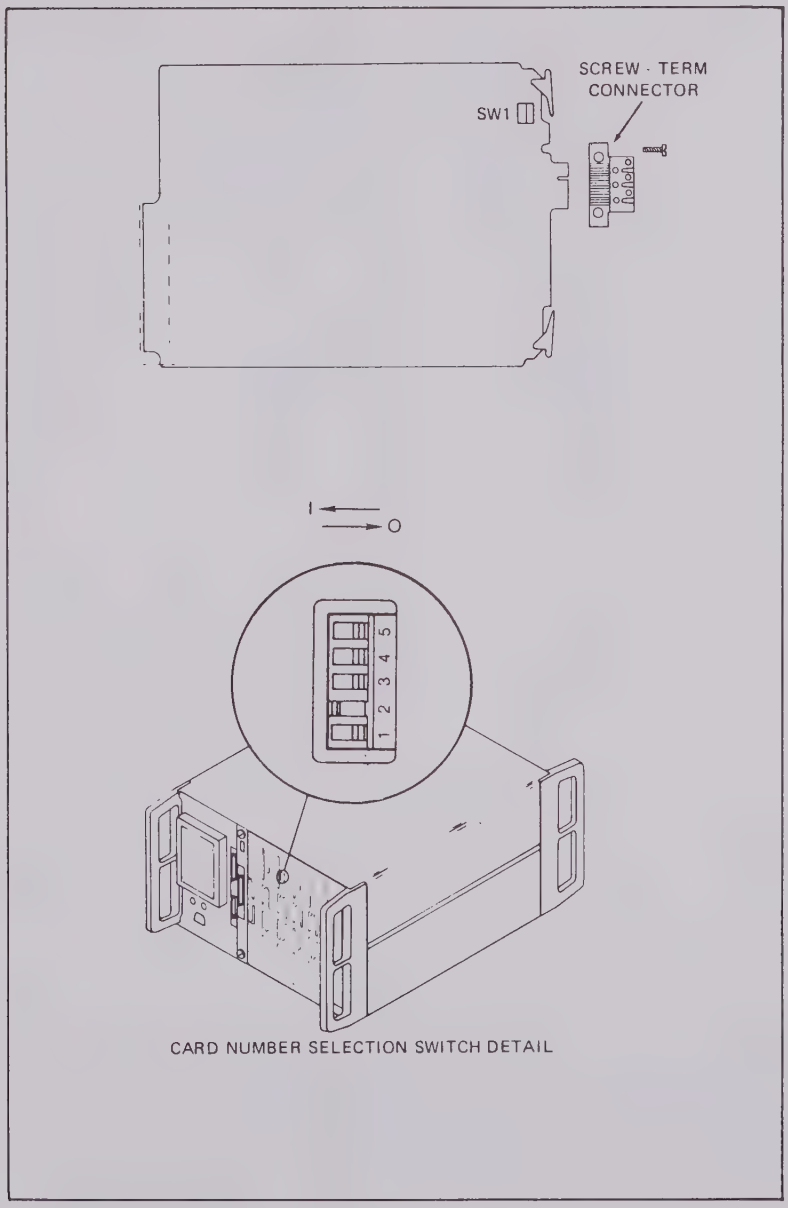


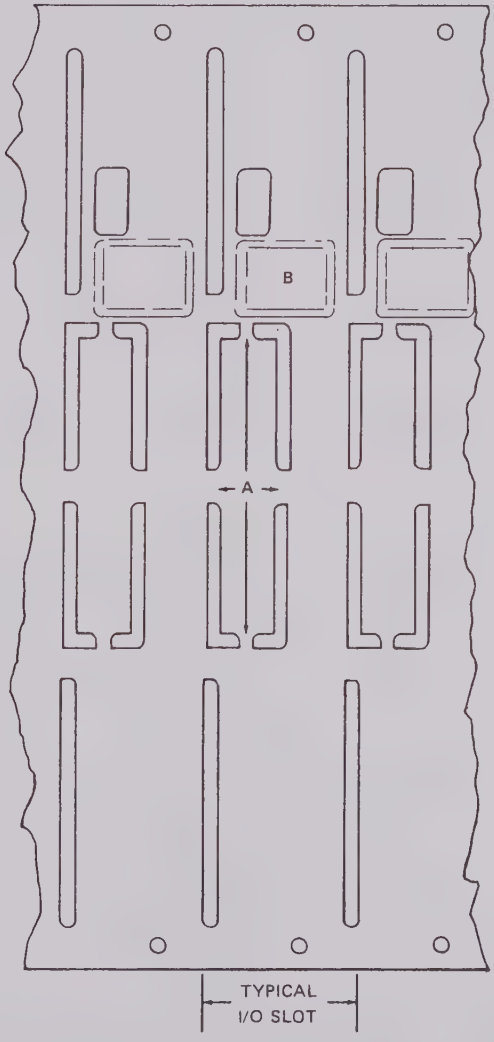
Figure 305-3. Address Switch Location

Table 305-2. Resistance Output Card Selection Switch Settings

S1 SWITCH SETTING = X X X X X LEFT = ONE, RIGHT = ZERO							
Card Number	Switch Segments					Resistance Output Channels Assigned:	
	B5	B4	B3	B2	B1	Channel A	Channel B
0	0	0	0	0	0	0	1
1	0	0	0	0	1	2	3
2	0	0	0	1	0	4	5
3	0	0	0	1	1	6	7
4	0	0	1	0	0	8	9
5	0	0	1	0	1	10	11
6	0	0	1	1	0	12	13
7	0	0	1	1	1	14	15
8	0	1	0	0	0	16	17
9	0	1	0	0	1	18	19
10	0	1	0	1	0	20	21
11	0	1	0	1	1	22	23
12	0	1	1	0	0	24	25
13	0	1	1	0	1	26	27
14	0	1	1	1	0	28	29
15	0	1	1	1	1	30	31
16	1	0	0	0	0	32	33
17	1	0	0	0	1	34	35
18	1	0	0	1	0	36	37
19	1	0	0	1	1	38	39
20	1	0	1	0	0	40	41
21	1	0	1	0	1	42	43
22	1	0	1	1	0	44	45
23	1	0	1	1	1	46	47
24	1	1	0	0	0	48	49
25	1	1	0	0	1	50	51
26	1	1	0	1	0	52	53
27	1	1	0	1	1	54	55
28	1	1	1	0	0	56	57
29	1	1	1	0	1	58	59
30	1	1	1	1	0	60	61
31	1	1	1	1	1	62	63

Installation Verification Test

Use the following procedure to verify proper installation of the Resistance Output assembly. Refer the 2400B Programming Guide for an explanation of the 2400B commands used. You will need a digital multimeter (DMM), such as the Fluke 8020A, the Fluke 70 Series, or equivalent.



1. CUT LOCATIONS A FOR I/O OPTIONS.
2. OPTION IDENTIFIER DECALS GO AT B.

Figure 305-4. Rear Panel Detail

1. Connect the V/K ohm lead of the DMM to a Resistance Output terminal. Connect the COMMON lead of the DMM to the other Resistance Output Terminal. Set the DMM to the ohms mode, in the lowest range to read 1000 ohms (or 1000 ohms plus offset resistance, if used).

2. Turn the 2400B power on. The output reading on the DMM should be 0 ohms (or the value of the offset resistor if installed).

3. Addressing the 2400B through the host device, enter the command:

   RO(channel #) = 1000!

   Where "channel #" is the channel number of the output under test.

4. Verify that the output equals 1000 ohms (plus the value of the offset resistor if installed.)

5. Set the DMM to the lowest scale that will read 4095 ohms (plus offset resistance, if used).

6. Enter the command:

   RO(channel #) = 4095!

7. Verify that the output equals 4095 ohms (plus offset resistance, if used). Refer to the 2400B Programming Guide for a detailed explanation of the 2400B commands used above.

Table 305-3. Resistance Output Connector Pin Assignments

PIN	SIGNAL
1	N/C
2	N/C
3	Channel B, Terminal 1
4	Channel B, Terminal 2
5	Channel A, Terminal 1
6	Channel A, Terminal 2

Service Information

All applicable service information is in the 2400B Service Manual.

OPTION 2400A-306 RESISTANCE OUTPUT (25 OHMS TO 100 KILOHMS)

Description

The 2400A-306 Resistance Output assembly is a pcb and output connector to be used as a control interface for applications requiring a programmable resistance from 0 to over 100,000 ohms. There are two variable resistance outputs for each pcb assembly. Each output is implemented with a 12-bit resistor ladder that is switched by reed relays to provide a two-terminal resistance from 0 to 102.375 kilohms in 25-ohm increments. Figure 306-1 gives an equivalent circuit for a 2400A-306 Resistance Output channel.

The pcb assembly mounts in any of the six I/O option slots in the back of the 2400B, or in any of the 12 I/O option slots in a 2402A chassis. By using 2402A I/O Extenders, a total of 32 Resistance Output assemblies (64 outputs) may be installed per system.

The output is accessible through the connector provided with the option. The connector has six screw terminals, with four used for the two outputs. Specifications for the Resistance Output assembly are given in Table 305-1.

Installation Notes

For applications requiring a non-zero minimum resistance output, an offest resistance may be added to the assembly by the user. To do this, a 1/8-watt metal film resistor or a 20-turn cermet potentiometer, or both of the devices, may be connected in series with the Resistance Output. The total resistance of these devices is called the offest resistance, and is added to the normal resistance of the Resistance Output.

To modify the low-numbered output (Channel A) of the Resistance Output assembly, follow the instructions in the next paragraph. The high-numbered output (Channel B) may be modified in the same way, by substituting Channel B components into the procedure. Examples: W1A becomes W1B; R20A becomes R20B.

To install a metal film resistor, locate and cut jumper W1A, then insert the resistor into the holes labeled R20A. To install a 20-turn cermet potentiometer, locate and cut jumper W2A, and insert the potentiometer terminals in the holes labeled R21A.

Installation

The Resistance Output pcb mounts in any of the available I/O option slots in the 2400B or 2402A chassis as Figure 306-2 shows. Follow this procedure to install the Resistance Output assembly:

Table 306-1. 2400A-306 Resistance Output Specifications

Outputs per Assembly	2 variable resistive outputs (see Figure 306-1)
Maximum Number of Channels per System (-305, -306 Total)	64 (2 per pcb, maximum of 32 assemblies per extended system).
Range	0 to 102,375 ohms
Resolution	25 ohms
Accuracy	±0.1% of full scale at output connector (as calibrated from the factory).
Calibration Interval	90 days at 18 to 28 degrees Celsius ambient temperature.
Temperature Coefficient	.005% of output/degree Celsius
Output Isolation	Each output is electrically isolated up to 30 volts. 1.0 Volt/microsecond maximum slew rate.
Maximum Power	1/8 watt per output
Output Protection	Output is set to a value of 0 ohms whenever power is interrupted or for 2 to 4 milliseconds whenever the output value is being changed.
Power Consumption	12.00 watts per assembly installed in the system.
Offset Resistance	Provision is made to allow user installation of an offset resistor on the Resistance Output PCB. This may be necessary for control applications requiring a non-zero output resistance at power down. For operation description, refer to the discussion in the Operation Reference Section (Section 5) of this manual.
Weight	0.4 kg. (1 lb.)
Environmental	Meets all the environmental specifications for the 2400

WARNING

TO AVOID ELECTRIC SHOCK REMOVE LINE POWER AND ALL OTHER HIGH-VOLTAGE INPUTS BEFORE CONTINUING.

1. Set the chassis POWER switch to OFF.
2. Remove the rear panel from the chassis.

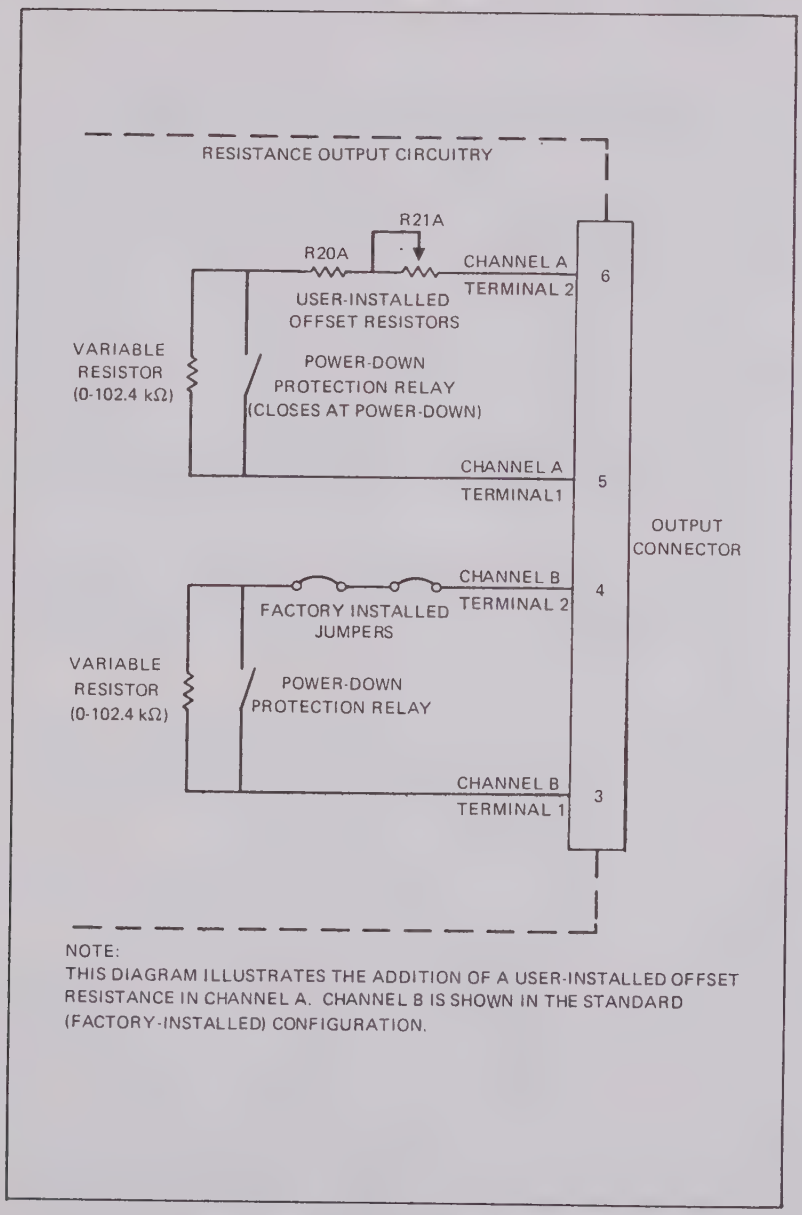


Figure 306-1. Equivalent Circuit of the Resistance Output

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

3. To select the best I/O option slot for mounting the 2400A-306 Resistance Output assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

4. Align the pcb in its selected I/O option slot so that its card-edge connector is toward the front of the chassis, and its subminiature, D-type connector is toward the back of the unit. Push the pcb into the chassis mating connector.

5. Locate the Card Select Switch on the pcb (see Figure 306-3) and assign a card number (consecutively starting with 0 for each Resistance Output assembly) to the pcb by setting the switches to the patterns shown in Table 306-2. The number selected will determine the output channels assigned to each pcb. Example: Card 0 provides outputs 0 and 1, Card 1 provides outputs 2 and 3, and so on.

6. After the Resistance Output assembly is installed, replace the rear panel, removing the rear panel cutouts as necessary. Attach the Option identification decal to the rear panel as Figure 306-4 shows.

7. Install the output connector.

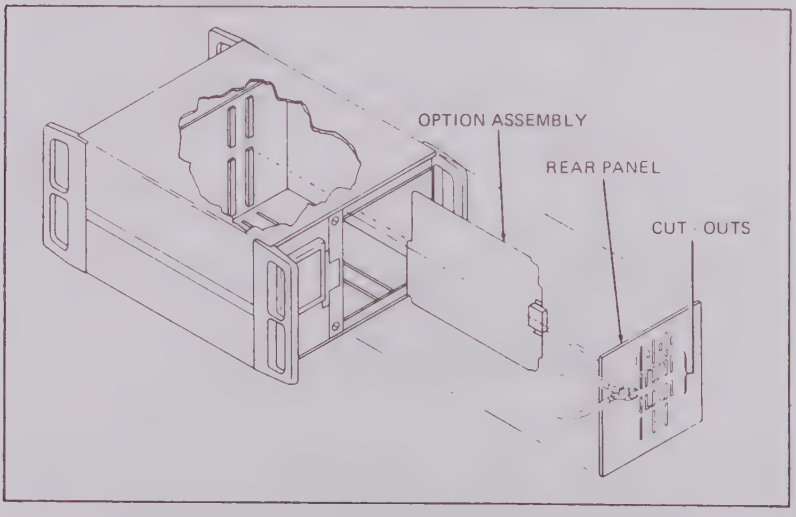


Figure 306-2. I/O Option Mounting Location

Operation

Once installed in the chassis, the Resistance Output assembly is ready for use. Complete the external connections from the screw terminal output connector to the device to be controlled. The pin assignments on the output connector are given in Table 306-3.

Familiarity with the 2400B command set is necessary to make full use of the Resistance Output assembly. Refer to the 2400B Programming Guide for an explanation of the commands and Resistance Output control functions.

Installation Verification Test

To verify proper installation of the 2400A-306 Resistance Output assembly, use the following procedure. To do the test, you will need a digital multimeter (DMM), such as the Fluke 8020A, the Fluke 70 Series, or equivalent.

1. Connect the V/K-ohm lead of the DMM to a Resistance Output terminal. Connect the COMMON lead of the DMM to the other Resistance Output Terminal. Set the DMM to the ohms mode in the lowest range to read 200 kilohms.

2. Turn on the 2400B power. The output should be 0 ohms (or the value of the offset resistor, if installed).

3. Addressing the 2400B through the host device, enter the following command:

   DEFN ROCHAN = <channel #>, RLSB = 25;!

   Where "channel #" represents the Resistance Output channel under test. For example, for Resistance Output channel 5 (channel B of card number two), the command would be:

   DEFN ROCHAN = 5, RLSB = 25; !

4. Enter the command:

   RO(channel #) = 25000!

5. Verify that the output equals 25 kilohms (plus offset resistance, if used).

6. Enter the command:

   RO(channel #) = 102.3E3 !

7. Verify that the output equals 102.3 kilohms (plus offset resistance, if used). Refer to the 2400B Programming Guide for a detailed explanation of the 2400B commands used above.

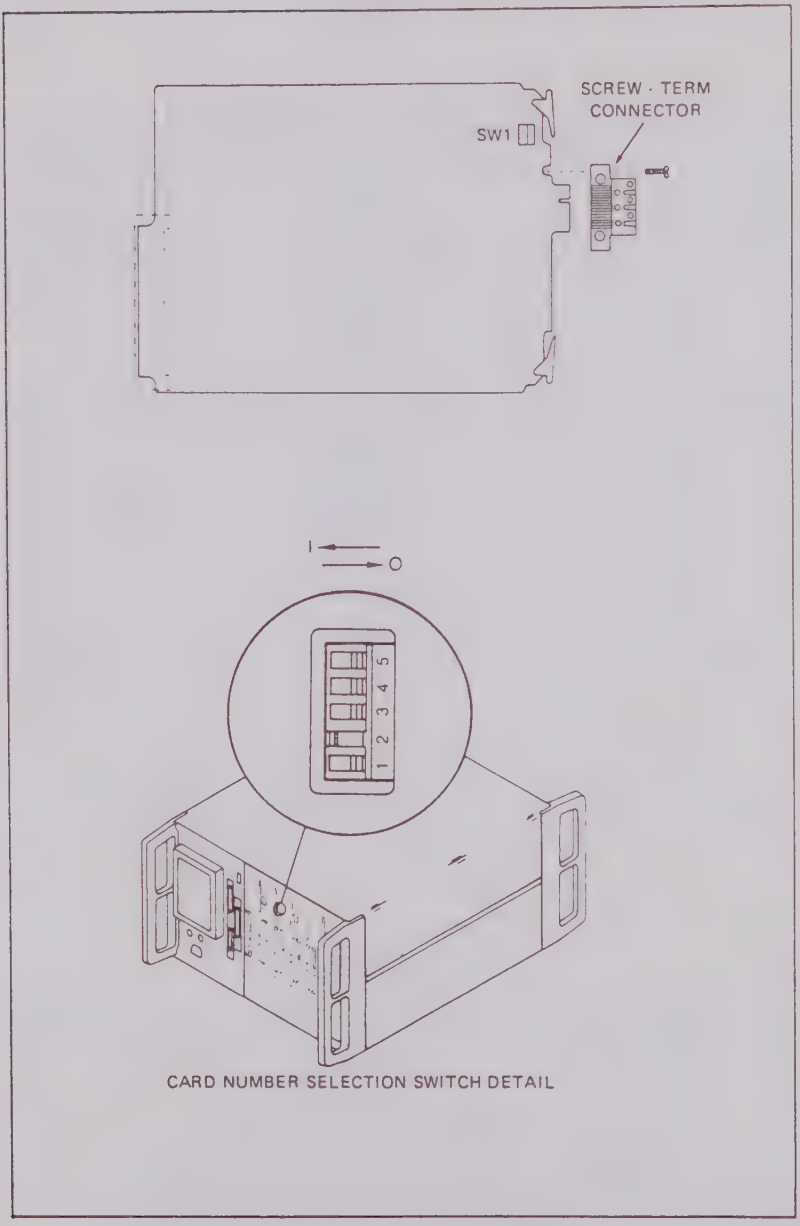


Figure 306-3. Address Switch Location

Table 306-2. Resistance Output Card Selection Switch Settings

S1 SWITCH SETTING = X X X X X LEFT = ONE, RIGHT = ZERO							
Card Number	Switch Segments					Resistance Output Channels Assigned:	
	B5	B4	B3	B2	B1	Channel A	Channel B
0	0	0	0	0	0	0	1
1	0	0	0	0	1	2	3
2	0	0	0	1	0	4	5
3	0	0	0	1	1	6	7
4	0	0	1	0	0	8	9
5	0	0	1	0	1	10	11
6	0	0	1	1	0	12	13
7	0	0	1	1	1	14	15
8	0	1	0	0	0	16	17
9	0	1	0	0	1	18	19
10	0	1	0	1	0	20	21
11	0	1	0	1	1	22	23
12	0	1	1	0	0	24	25
13	0	1	1	0	1	26	27
14	0	1	1	1	0	28	29
15	0	1	1	1	1	30	31
16	1	0	0	0	0	32	33
17	1	0	0	0	1	34	35
18	1	0	0	1	0	36	37
19	1	0	0	1	1	38	39
20	1	0	1	0	0	40	41
21	1	0	1	0	1	42	43
22	1	0	1	1	0	44	45
23	1	0	1	1	1	46	47
24	1	1	0	0	0	48	49
25	1	1	0	0	1	50	51
26	1	1	0	1	0	52	53
27	1	1	0	1	1	54	55
28	1	1	1	0	0	56	57
29	1	1	1	0	1	58	59
30	1	1	1	1	0	60	61
31	1	1	1	1	1	62	63

Table 306-3. Resistance Output Connector Pin Assignments

PIN	SIGNAL
1	N/C
2	N/C
3	High numbered RO channel, Terminal 1
4	High numbered RO channel, Terminal 2
5	Low numbered RO channel, Terminal 1
6	Low numbered RO channel, Terminal 2

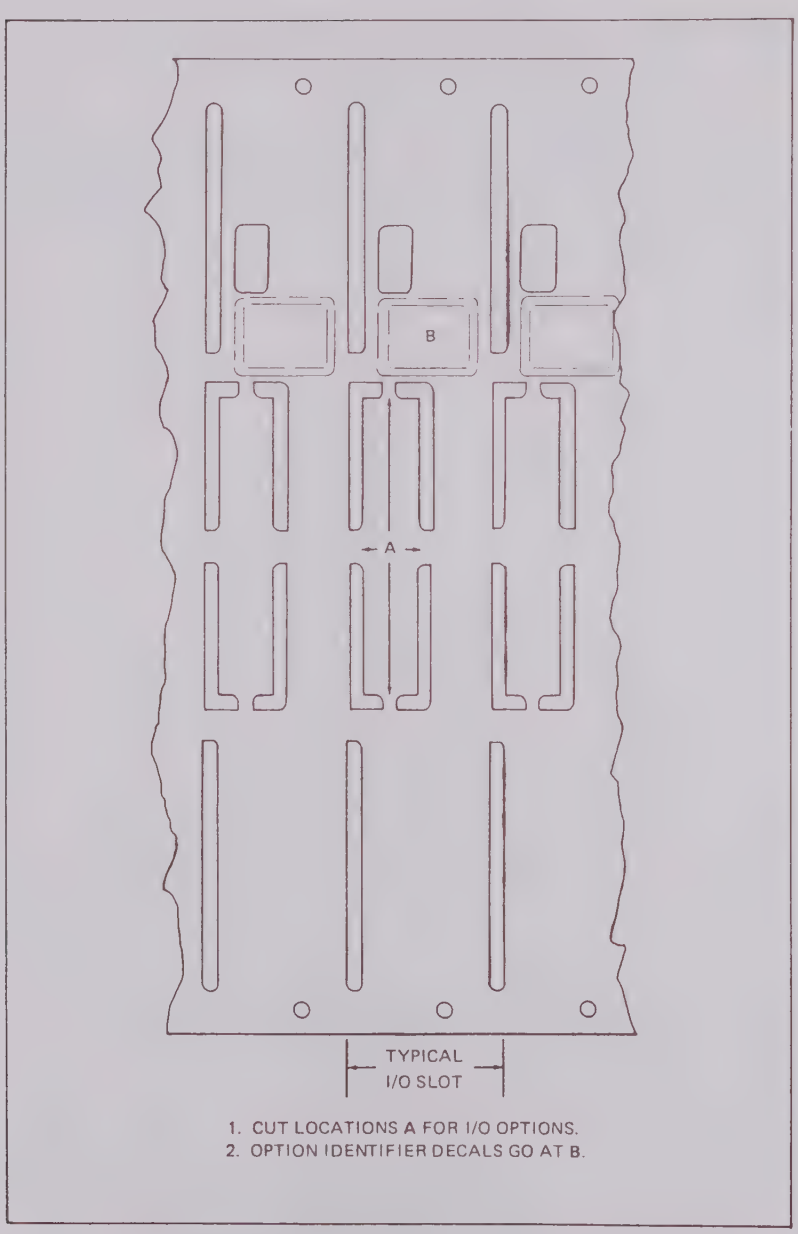


Figure 306-4 Rear Panel Detail

Service Information

All applicable service information is included in the 2400B Service Manual.

OPTION 2400A-307 STEPPER MOTOR CONTROLLER

Description

The Stepper Motor Controller allows the 2400B Intelligent Computer Front End to send control signals to an external stepper motor driver. The Stepper Motor Controller provides a single non-isolated output channel that is configurable with switches to make it compatible with all stepper motor drivers.

The Stepper Motor Controller is a single printed circuit board assembly and a connector. A set of 12 card-edge contacts at the rear of each assembly provide output connections. A terminal block style connector is provided to interface external equipment to the card-edge contacts.

The Stepper Motor Controller option is a pcb assembly that mounts in any of the six I/O option slots in the 2400B, or any of the 12 I/O option slots in a 2402A I/O Extender Chassis. By using 2402A I/O Extender Chassis, up to 32 assemblies (32 outputs) may be installed per system.

Table 307-1 lists specifications for the Stepper Motor Controller.

Table 307-1. Stepper Motor Controller Specifications

MAXIMUM NUMBER OF OUTPUT CHANNELS	
Per Assembly	One nonisolated output channel.
Per System	32 (1 output per assembly, and 32 assemblies per system.)
INPUT SIGNALS	External Enable Input Feedback Clock Input Flyback Protection Diode Input
INPUT LOGIC	Pull-up resistors are installed to terminate unused inputs.
INPUT LOGIC LEVELS	CMOS inputs with static protection. Compatible with LSTTL and CMOS logic operated from 5V to 15V.
Logic 0	0 to 0.75V
Logic 1	3.5V to 15V

Table 307-1. Stepper Motor Controller Specifications (cont.)

FEEDBACK CLOCK INPUT TIMING	Positive going pulse ≥10 microseconds. Frequency equivalent to output step frequency.
OUTPUT SIGNALS	Output 1 (STEP or STEP CW) Output 2 (CW/CCW or STEP CCW) BUSY MD1 through MD4
OUTPUT LOGIC	Open-collector TTL outputs allow interface with circuits using power supply voltages up to 15V dc.
MOTOR DRIVE OUTPUTS	Open-collector darlington transistor arrays capable of sinking up to 375 milliamperes with a maximum saturation voltage of 1.5 V dc. The motor drive voltage may be up to 30V dc.
PROGRAMMABLE SLEW FREQUENCY	1.0 Hz to 25,600 Hz in three ranges for optimum resolution.
SLEW FREQUENCY RESOLUTION	1.0 Hz from 1.0 Hz to 256 Hz 10 Hz from 10 Hz to 2560 Hz 100 Hz from 100 Hz to 25600 Hz
OUTPUT FREQUECY ACCURACY	±0.35% of full scale of selected range (90 days, 18 to 28 degreesCelsius).
OUTPUT FREQUENCY MAXIMUM NONLINEARITY	±0.075% of full scale of selected range (included in accuracy statement).
MONOTONICITY	Monotonic over full range.
TEMPERATURE STABILITY	±250 ppm / degree Celsius maximum (included in accuracy statement).
ACCELERATION AND DECELERATION RATES	Sixteen rates in each of the three frequency ranges from 0.1149 kHz/s to 97.66 kHz/s.
NUMBER OF OUTPUT PULSES	1 to 2^{20} -1 pulses either in the clockwise or counterclockwise directions.
POWER CONSUMPTION	10 watts per assembly added to the system.
WEIGHT	0.4 Kg (1 lb.)
ENVIRONMENTAL	Meets all environmental specifications of the Model 2400

Installation Notes

The two control outputs (OUTPUT1 and OUTPUT2) are configured by the four switch segments of S2, shown in Figure 307-1. The configuration of S2 determines the function and logical polarity of the control signals to the stepper motor driver assembly. See Tables 307-2 and 307-3 for descriptions of the available output signals.

Before installing the Stepper Motor Controller, check the configuration of these switches. Determine the configuration of the outputs by comparing the switch positions of S2 to the information listed in Tables 307-2 and 307-3. The tables refer to card-edge connector J48. See Figure 307-1 for the location of S2.

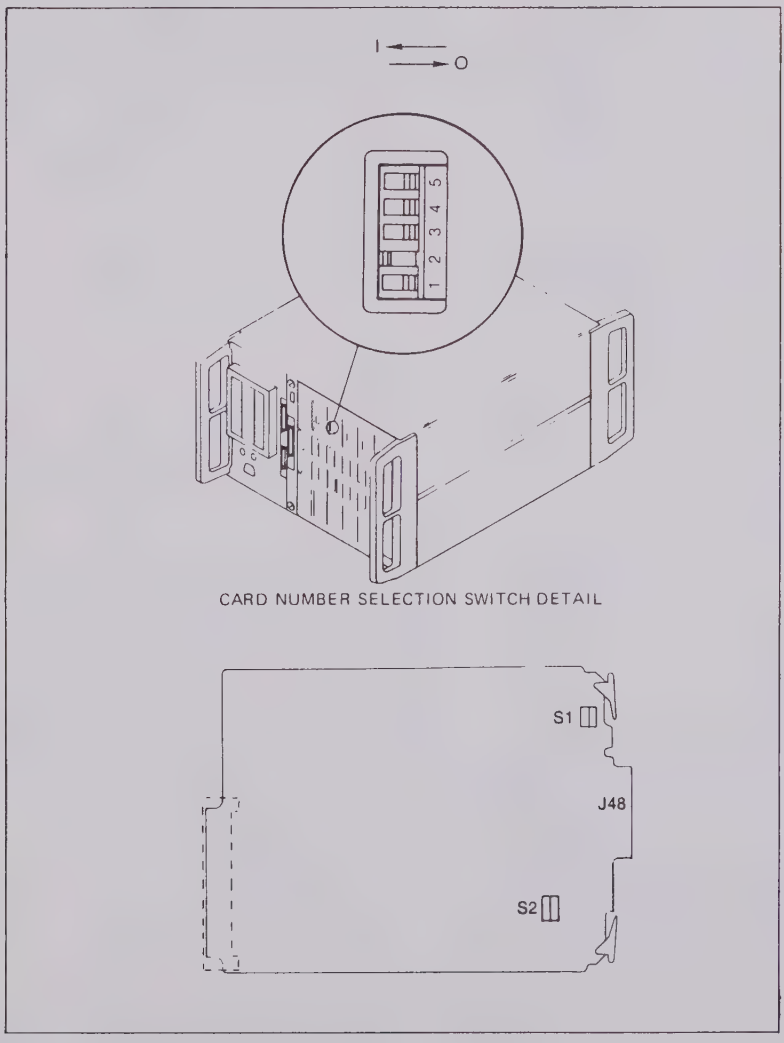


Figure 307-1. Card Select Switch Location

Table 307-2. Switch Settings for Seperate Step Clock and Direction Control Outputs

MOTOR CONTROL OUTPUT FUNCTIONS	OUTPUT 1 CONTROL		OUTPUT 2 CONTROL	
	S2-2 POSITION (FUNCTION)	S2-3 POSITION (POLARITY)	S2-4 POSITION (FUNCTION)	S2-5 POSITION (POLARITY)
Positive step clock signal at Output 1 (J48-5) and CW/$\overline{\text{CCW}}$ direction signal at Output 2 (J48-6).	STP	+	DIR	+
Negative step clock signal at Output 1 (J48-5) and CW/$\overline{\text{CCW}}$ direction signal at Output 2 (J48-6).	STP	—	DIR	+
Positive step clock signal at Output 1 (J48-5) and $\overline{\text{CW}}$/CCW direction signal at Output 2 (J48-6).	STP	+	DIR	—
Negative step clock signal at Output 1 (J48-5) and $\overline{\text{CW}}$/CCW direction signal at Output 2 (J48-6).	STP	—	DIR	—

Table 307-3. Switch Settings for Step Clock Signals of Opposite Direction at Each Output

MOTOR CONTROL OUTPUT FUNCTIONS (OUTPUT 1 AND OUTPUT 2 ARE MUTUALLY EXCLUSIVE)	OUTPUT 1 CONTROL		OUTPUT 2 CONTROL	
	S2-2 POSITION (FUNCTION)	S2-3 POSITION (POLARITY)	S2-4 POSITION (FUNCTION)	S2-5 POSITION (POLARITY)
Positive step clockwise signal at Output 1 (J48-5) and positive step counter-clockwise signal at Output 2 (J48-6).	CW	+	CCW	+
Positive step clockwise signal at Output 1 (J48-5) and positive step counter-clockwise signal at Output 2 (J48-6).	CW	+	CCW	—
Negative step clockwise signal at Output 1 (J48-5) and negative step counter-clockwise signal at Output 2 (J48-6).	CW	—	CCW	+
Negative step clockwise signal at Output 1 (J48-5) and negative step counter-clockwise signal at Output 2 (J48-6).	CW	—	CCW	—

The Stepper Motor Controller may be configured as a closed-loop system with unity feedback by setting switch S2-1 (located at the top section of S2 shown in Figure 307-1) to the CLOSED position. With S2-1 in the OPEN position, the feedback path is internal and in this case does not reflect actual motor movement.

Installation

The Stepper Motor Controller mounts in any available I/O option slot in the 2400B or the 2402A as Figure 307-2 shows. Follow this procedure to install the assembly:

1. Set the chassis POWER switch to OFF.

WARNING

TO AVOID ELECTRIC SHOCK REMOVE LINE POWER AND ALL OTHER HIGH VOLTAGE INPUTS TO THE CHASSIS BEFORE CONTINUING.

2. Remove all connectors and cables from the rear panel.

Caution

Handle the assembly by its edges to avoid contaminating the pcb with oil from the hands. The use of gloves is recommended.

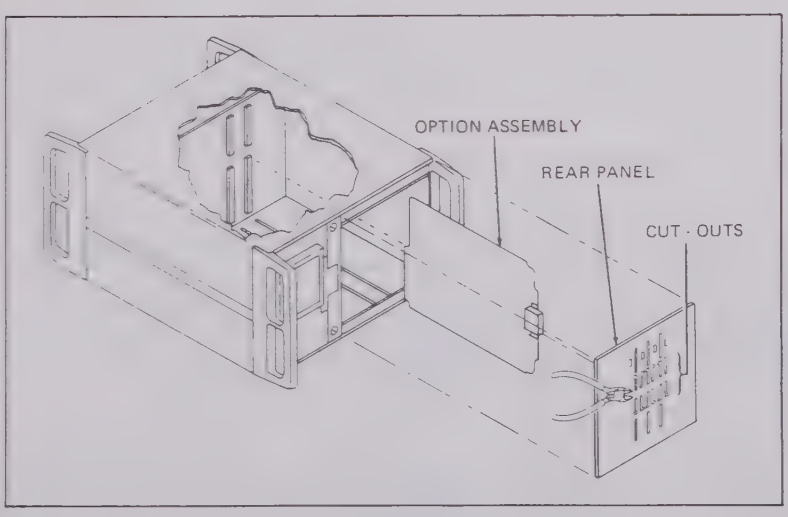


Figure 307-2. I/O Output Mounting Locations

3. To select the best I/O option slot for mounting the Stepper Motor Controller assembly, follow the guidelines under the heading, "Selecting I/O Option Slots" in Section 3, Installation.

4. Align the pcb assembly in its selected I/O option slot so that its offset card-edge connector is toward the front of the chassis, and its centered card-edge connector is toward the back of the unit. Push the pcb assembly into the chassis mating connector.

5. Locate the Card Select Switch S1 on the pcb assembly, shown in Figure 307-2, and assign a card number (consecutively starting with 0, for each Stepper Motor Controller in the system) to the pcb assembly by setting the switches as listed in Table 307-4. The card number is equal to the Stepper Motor Controller channel number. Example: Card 0 provides channel 0, Card 1 provides channel 1, etc.

6. After the Stepper Motor Controller is installed, install the rear panel, removing the rear panel connector cutout as necessary. Attach the option identification decal to the rear panel.

Operation

GENERAL

Once installed in the chassis, the Stepper Motor Controller is ready for use. Connect the external wiring to the device to be controlled using the terminal block connector. Pin assignments for the terminal block connector are listed in Table 307-5.

The 2400B command set operates the Stepper Motor Controller. Therefore, an understanding of the 2400B commands is necessary to operate the Stepper Motor Controller. Refer to the 2400B Programming Guide for applications of Stepper Motor Controller functions and an explanation of the command set.

CLOSED-LOOP OPERATION

To ensure that a stepper motor actually rotates the desired number of steps, the Stepper Motor Controller may be configured as a closed-loop system. An incremental encoder may be attached to the shaft of the stepper motor, and the encoder output may be used to generate a signal suitable for driving the Feedback Clock Input on the Stepper Motor Controller. This allows the Stepper Motor Controller to output step pulses until the desired number of motor steps (as detected by the shaft encoder) is observed through the Feedback Clock Input signal.

EXTERNALLY ENABLED OPERATION

When synchronization through hardware is desired, the External Enable Input may be used to initiate a previously programmed step sequence. The External Enable Input can be manually set, and in some applications, the External Enable Input may be controlled by a motor position limit switch or an alarm circuit.

A step sequence starts only when the External Enable is high. If the External Enable Input goes low during a step sequence, the Stepper Motor Controller immediately disables its outputs to protect the connected stepper motor. If the Stepper Motor Controller is operating in the open-loop mode, the step sequence continues to completion, although no more step pulses are output. If the Stepper Motor Controller is operating in the closed-loop mode, a logic low to the External Enable Input disables the outputs, and the step sequence stops unless pulses continue to be detected on the Feedback Input.

Table 307-4. Stepper Motor Controller Card Selection Switch (S1) Settings

LEFT = ONE, RIGHT = ZERO S1 SWITCH SETTING = X X X X X						
CARD NUMBER	SWITCH SEGMENTS					STEPPER MOTOR CONTROLLER
	B5	B4	B3	B2	B1	
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	0	0	1	0	2
3	0	0	0	1	1	3
4	0	0	1	0	0	4
5	0	0	1	0	1	5
6	0	0	1	1	0	6
7	0	0	1	1	1	7
8	0	1	0	0	0	8
9	0	1	0	0	1	9
10	0	1	0	1	0	10
11	0	1	0	1	1	11
12	0	1	1	0	0	12
13	0	1	1	0	1	13
14	0	1	1	1	0	14
15	0	1	1	1	1	15
16	1	0	0	0	0	16
17	1	0	0	0	1	17
18	1	0	0	1	0	18
19	1	0	0	1	1	19
20	1	0	1	0	0	20
21	1	0	1	0	1	21
22	1	0	1	1	0	22
23	1	0	1	1	1	23
24	1	1	0	0	0	24
25	1	1	0	0	1	25
26	1	1	0	1	0	26
27	1	1	0	1	1	27
28	1	1	1	0	0	28
29	1	1	1	0	1	29
30	1	1	1	1	0	30
31	1	1	1	1	1	31

FOUR-PHASE OUTPUT OPERATION

There is one set of low power four-phase motor driver outputs (MD1-MD4) available on the Stepper Motor Controller. The four-phase outputs are each capable of sinking up to 375 milliamperes of current, enough to drive a small stepper motor or a higher current four-phase motor driver. The four-phase output sequence is shown in Table 307-6.

The Stepper Motor Controller has flyback protection diodes available for termination. To use the protection diodes, connect the motor drive power supply (up to +30 volts dc) to J48-11 using the terminal block style connector for access. Notice that the Stepper Motor Controller does not source the current to energize the stepper motor windings. That current must be supplied by an external power supply.

Table 307-5. Stepper Motor Controller Pin Assignments

J48 PIN NO.	SIGNAL NAME
1	Feedback Clock Input
2	External Enable Input
3	$\overline{\text{BUSY}}$ Output
4	Not used
5	Output 1
6	Output 2
7	Motor Driver 1 (MD1)
8	Motor Driver 2 (MD2)
9	Motor Driver 3 (MD3)
10	Motor Driver 4 (MD4)
11	Flyback Diode Termination
12	Logic Common

Table 307-6. Four Phase Output Sequence

DIRECTION	STATE OF OUTPUTS			
	MD1	MD2	MD3	MD4
CW ↓ ↑ CCW	ON	ON	OFF	OFF
	OFF	ON	ON	OFF
	OFF	OFF	ON	ON
	ON	OFF	OFF	ON
	ON	ON	OFF	OFF

Installation Verification Test

To verify the proper installation of the Stepper Motor Controller, use the following procedure. Refer to the 2400B Programming Guide for an explanation of the commands used in this test.

1. Remove any cabling from the output connector.

2. Verify that S2-1 on the Stepper Motor Controller is in the OPEN position.

3. Depress the POWER switch on the front panel of the 2400B.

4. Address the 2400B through the host device, and enter the command:

```
SEND SMF(channel #),SMAD(channel #),SMO(channel #)!
```

   Where "channel #" is the card number of the Stepper Motor Controller to be tested.

5. Verify that the values returned by the 2400B equal 100, 97656.3, and 0, respectively.

6. Enter the commands:

```
SMED(channel #) = 0!
SMF(channel #) = 25000!
SMO(channel #) = 50000!
```

7. Enter the command:

```
SEND SMO(channel #)!
```

8. Verify that the value returned is 50000.

9. Enter the command:

```
SMED(channel #)=1!
```

10. Wait two seconds and then enter the command:

```
SEND SMO(channel #)!
```

11. Verify that the value returned is 0.

This completes the installation verification test.

Service Information

Calibration procedure, troubleshooting procedure, parts list, schematics, and theory of operation are presented in the 2400B Service Manual.

SECTION 10

INSTALLATION QUICK REFERENCE

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OPTION PIN ASSIGNMENTS

In this section has a compilation of pin assignments for options. The options that are included here are those whose user-connectable terminal assignments are not printed on the label on the option.

2400A-103, Digital Input Option

PIN	SIGNAL	PIN	SIGNAL
1	Input bit 0	26	Input bit 13
2	Input bit 1	27	Input bit 14
3	Input bit 2	28	Input bit 15
4	Input bit 3	29	Logic Common
5	Input bit 4	30	Logic Common
6	Input bit 5	31	Input bit 16
7	Input bit 6	32	Input bit 17
8	Input bit 7	33	Input bit 18
9	LOAD 1	34	Input bit 19
10	Invert LOAD 1	35	Input bit 20
11	ACK1	36	Input bit 21
12	LOAD2	37	Input bit 22
13	Invert LOAD 2	38	Input bit 23
14	ACK2	39	Logic Common
15	LOAD3	40	Logic Common
16	Invert LOAD3	41	Input bit 24
17	BUSY	42	Input bit 25
18	Invert BUSY	43	Input bit 26
19	Invert ACK1, ACK2	44	Input bit 27
20	Single/Continuous	45	Input bit 28
21	Input bit 8	46	Input bit 29
22	Input bit 9	47	Input bit 30
23	Input bit 10	48	Input bit 31
24	Input bit 11	49	Logic Common
25	Input bit 12	50	Logic Common

2400A-104, Status Input Option

PIN	SIGNAL	PIN	SIGNAL
1	Input 0	26	Input 13
2	Input 1	27	Input 14
3	Input 2	28	Input 15
4	Input 3	29	Isolated Common
5	Input 4	30	Isolated Common
6	Input 5	31	Input 16
7	Input 6	32	Input 17
8	Input 7	33	Input 18
9	Isolated Common	34	Input 19
10	Isolated Common	35	Input 20
11	Isolated Common	36	Input 21
12	Isolated Common	37	Input 22
13	Isolated Common	38	Input 23
14	Isolated Common	39	Isolated Common
15	Isolated Common	40	Isolated Common
16	Isolated Common	41	Input 24
17	Isolated Common	42	Input 25
18	Isolated Common	43	Input 26
19	Isolated Common	44	Input 27
20	Isolated Common	45	Input 28
21	Input 8	46	Input 29
22	Input 9	47	Input 30
23	Input 10	48	Input 31
24	Input 11	49	Isolated Common
25	Input 12	50	Isolated Common

2400A-110, Screw Terminal Input Connector

D CONNECTOR PIN	SCREW TERMINAL NUMBER	D CONNECTOR PIN	SCREW TERMINAL NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

2400A-111, Solder Pin Input Connector

D CONNECTOR PIN	SOLDER PIN NUMBER	D CONNECTOR PIN	SOLDER PIN NUMBER
1	1	26	26
2	2	27	27
3	3	28	28
4	4	29	29
5	5	30	30
6	6	31	31
7	7	32	32
8	8	33	33
9	9	34	34
10	10	35	35
11	11	36	36
12	12	37	37
13	13	38	38
14	14	39	39
15	15	40	40
16	16	41	41
17	17	42	42
18	18	43	43
19	19	44	44
20	20	45	45
21	21	46	46
22	22	47	47
23	23	48	48
24	24	49	49
25	25	50	50

2400A-113, Counter/Totalizer Input Option

TERMINAL	SIGNAL	COMMON TERMINAL
1	Common (Isolated)	N.A.
2	Analog Input	1
3	Overflow	12
4	Gate 1	12
5	Gate 2	12
6	Trigger	12
7	Count Up	12
8	Count Down	12
9	Up / Down	12
10	Count	12
11	TTL Input	12
12	Common (Non-Isolated)	N.A.

2400A-114, Interrupt Input Option

PIN	SIGNAL	PIN	SIGNAL
1	Input 0	26	Input 13
2	Input 1	27	Input 14
3	Input 2	28	Input 15
4	Input 3	29	Not Connected
5	Input 4	30	Not Connected
6	Input 5	31	Not Connected
7	Input 6	32	Not Connected
8	Input 7	33	Not Connected
9	Isolated Common	34	Not Connected
10	Isolated Common	35	Not Connected
11	Isolated Common	36	Not Connected
12	Isolated Common	37	Not Connected
13	Isolated Common	38	Not Connected
14	Isolated Common	39	Isolated Common
15	Isolated Common	40	Isolated Common
16	Isolated Common	41	Not Connected
17	Isolated Common	42	Not Connected
18	Isolated Common	43	Not Connected
19	Isolated Common	44	Not Connected
20	Isolated Common	45	Not Connected
21	Input 8	46	Not Connected
22	Input 9	47	Not Connected
23	Input 10	48	Not Connected
24	Input 11	49	Isolated Common
25	Input 12	50	Isolated Common

2400A-301, Status Output Option

PIN	SIGNAL	PIN	SIGNAL
1	Output 0	26	Output 13
2	Output 1	27	Output 14
3	Output 2	28	Output 15
4	Output 3	29	Flyback Protection Outputs 8-15
5	Output 4	30	Isolated Common
6	Output 5	31	Output 16
7	Output 6	32	Output 17
8	Output 7	33	Output 18
9	Flyback Protection Outputs, 0-7.	34	Output 19
10	Isolated Common	35	Output 20
11	Polarity Select	36	Output 21
12	Isolated Common	37	Output 22
13	Isolated Common	38	Output 23
14	Isolated Common	39	Flyback Protection Outputs 16-23
15	Isolated Common	40	Isolated Common
16	Isolated Common	41	Output 24
17	Isolated Common	42	Output 25
18	Isolated Common	43	Output 26
19	Isolated Common	44	Output 27
20	Isolated Common	45	Output 28
21	Output 8	46	Output 29
22	Output 9	47	Output 30
23	Output 10	48	Output 31
24	Output 11	49	Flyback Protection Outputs 24-31
25	Output 12	50	Isolated Common

2400A-302, Voltage/Current Analog Output Option

PIN	SIGNAL	PIN	SIGNAL
50	+ Voltage Output A	22	- Current Output C
49	- Voltage Output A	40	Test Point 26C
32	+ Voltage Sense A	41	Test Point 26C
31	- Voltage Sense A	6	Test Point 27C
17	+ Current Output A	9	Not Used
16	- Current Output A	1	+ Voltage Output D
47	Test Point 26A	2	- Voltage Output D
48	Test Point 26A	19	+Voltage Sense D
33	Test Point 27A	18	- Voltage Sense D
3	Not Used	35	+ Current Output D
12	+ Voltage Output B	20	- Current Output D
13	- Voltage Output B	36	Test Point 26D
28	+ Voltage Sense B	37	Test Point 26D
29	- Voltage Sense B	34	Test Point 27D
10	+ Current Output B	14	Not Used
27	- Current Output B	15	Not Used
44	Test Point 26B	21	Not Used
45	Test Point 26B	25	Not Used
11	Test Point 27B	26	Not Used
4	Not Used	30	Not Used
7	+ Voltage Output C	38	Not Used
8	- Voltage Output C	39	Not Used
23	+ Voltage Sense C	42	Not Used
24	- Voltage Sense C	43	Not Used
5	+ Current Output C	46	Not Used

2400A-305, Resistance Output Option (1 Ohm to 4 Kilohms), and

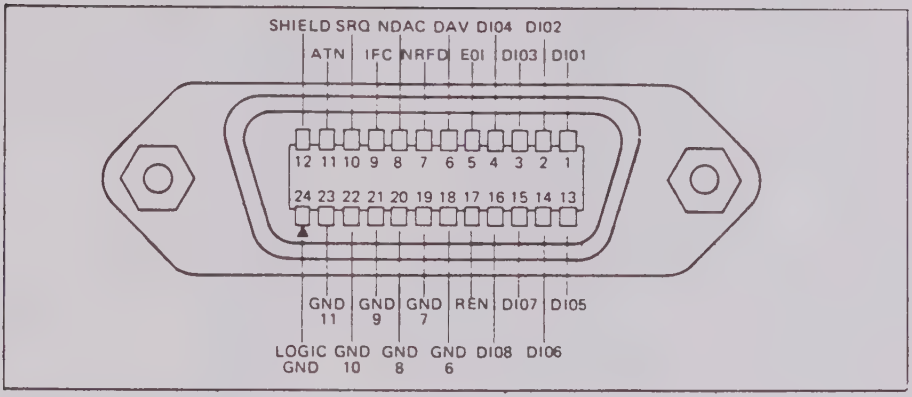
2400A-306, Resistance Output Option (25 Ohms to 100 Kilohms)

PIN	SIGNAL
1	N/C
2	N/C
3	Channel B, Terminal 1
4	Channel B, Terminal 2
5	Channel A, Terminal 1
6	Channel A, Terminal 2

2400A-307, Stepper Motor Controller

J48 PIN NO.	SIGNAL NAME
1	Feedback Clock Input
2	External Enable Input
3	$\overline{\text{BUSY}}$ Output
4	Not used
5	Output 1
6	Output 2
7	Motor Driver 1 (MD1)
8	Motor Driver 2 (MD2)
9	Motor Driver 3 (MD3)
10	Motor Driver 4 (MD4)
11	Flyback Diode Termination
12	Logic Common

IEEE-488 PIN ASSIGNMENTS



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Appendix B

2400B Specifications

Access	All mainframe and option assemblies (with the exception of the Display assembly) are removable from the rear of the chassis.
Size	22 cm High x 43 cm Wide x 38 cm Deep (8.66 in High x 16.9 in wide x 14.96 in Deep.) The 2400A is compatible with a standard 19-inch equipment rack. See Figure 1-3.
Weight	Approximately 13.7 kg. (25 lbs).

OPERATING CHARACTERISTICS

Power	120V or 240V ac +10%, -25%, selectable at 50 or 60 Hz ± 2 Hz.
Maximum Power Consumption	Less than 70 watts without options installed, less than 130 watts with options installed.
Warm Up Time to Rated Accuracy	45 minutes. Derate all accuracy figures by 2:1 for the first 30 minutes of operation. Accuracy improves linearly between 30 and 45 minutes.

NOTE: Analog Input readings do not reach rated accuracy for a period of 15 seconds after power-up or reset. System initialization is being performed during this time, and readings should not be requested.

ENVIRONMENTAL REQUIREMENTS

Temperature	
OPERATING	0 to 50 degrees Celsius operating
STORAGE	-20 to 70 degrees Celsius storage.
RELATIVE HUMIDITY	0 to 80% up to 40 degrees Celsius (non-condensing) 0 to 70% up to 50 degrees Celsius operating.
Shock and Vibration	Meets MIL-T-28800A, class 4 standards.

GENERAL SPECIFICATIONS

Inputs/Outputs	All input/output connections are accessible from the rear of the chassis.

Appendix C

2400B Quick Reference Error Messages

This is an abbreviated form of the 2400B Error Messages for use as a quick reference. If more detailed information is needed about any of the error messages, refer to the 2400B Programming Reference.

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
SYSTEM	1	(ln)	-1	Insufficient memory.
	3	0	(leg #)	2402A I/O extender power failure.
	4	0	-1	2400B over temperature.
	5	0	-1	A/D self test voltage out of specifications.
	6	0	-1	Operating system error.
	7	0	-1	Too many errors in log.
	8	0	(ROM #)	2400B mainframe checksum error.
	9	0	-1	Internal command terminator error.
	10	0	-1	External transmission error.
	11	0	-1	Serial interface ROM checksum error.
I/O	101	(ln)	(cn)	Nonexistent analog input channel.
	102	(ln)	(cn)	Open thermocouple.
	103	(ln)	(cn)	Scanner failure to respond.
	104	(ln)	(cn)	Signal conditioner failure to respond.
	105	(ln)	(cn)	A/D overrange.
	106	(ln)	(cn)	Bad reference transistor reading.
	107	(ln)	(cn)	Guarded controller failure to respond.
	108	(ln)	(cn)	Thermocouple linearization overflow.
	109	(ln)	(cn)	Thermocouple linearization underflow.
	111	(ln)	(cn)	Nonexistent analog input channel.
	112	(ln)	(cn)	Attempt to set analog output out of range.
	121	(ln)	(cn)	Nonexistent digital input channel.
	122	(ln)	(cn)	Illegal BCD digit on digital input channel.
	131	(ln)	(cn)	Nonexistent status input channel.
	141	(ln)	(cn)	Nonexistent status output channel.
	151	(ln)	(cn)	Nonexistent resistance output channel.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
I/O	152	(ln)	(cn)	Attempted resistance output beyond range.
	161	(ln)	(cn)	Illegal self-test voltage channel.
	171	(ln)	(cn)	RTD resistance out of range.
	175	(ln)	(cn)	Invalid strain definition.
	176	(ln)	(cn)	Strain gauge strained beyond allowable percentage limit.
	177	(ln)	(cn)	Strain initialization not compatible with channel definition.
	181	(ln)	(cn)	Nonexistent interrupt input channel.
	182	(ln)	0 or 1	Change in interrupt input card address configuration (card no. 0 or 1).
	191	(ln)	(cn)	Nonexistent counter/totalizer channel.
	192	(ln)	(cn)	Illegal counter/totalizer reading.
	193	(ln)	(cn)	Illegal totalizer preset.
	195	(ln)	(cn)	Nonexistent stepper motor channel.
	196	(ln)	(cn)	Stepper motor output out of range.
	197	(ln)	(cn)	Stepper motor frequency out of range.
	198	(ln)	(cn)	Stepper acceleration/deceleration out of range.
ARITH	201	(ln)	-1	Arithmetic overflow.
	202	(ln)	-1	Arithmetic underflow.
	203	(ln)	-1	Divide by zero.
	204	(ln)	-1	Square root parameter less than zero.
	205	(ln)	-1	LOG or LN parameter < or = zero.
	206	(ln)	(value)	Array subscript out of range.
	207	(ln)	-1	Inverse sine (cosine) of number > 1.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
BUFFER	301	(ln)	(bn)	Nonexistent buffer.
	302	(ln)	(bn)	Buffer unavailable now (cannot be opened).
	303	(ln)	(bn)	Buffer full.
	304	(ln)	(bn)	Buffer already defined.
	305	(ln)	(pn)	Invalid print port number.
	306	(ln)	(pn)	PRINT timeout.
SYNTAX	401	(ln)	-1	Illegal character received from Host.
	402	(ln)	-1	Identifier too long.
	403	(ln)	-1	Illegal number.
	404	(ln)	-1	String too long.
	405	(ln)	-1	Illegal function parameter or array index.
	406	(ln)	-1	Ill-formed arithmetic expression.
	407	(ln)	-1	Mismatched parenthesis.
	408	(ln)	-1	Bad information to SEND, BUFFER or PRINT.
	409	(ln)	-1	Illegal string.
	410	(ln)	-1	Bad TISTAT parameter.
	411	(ln)	-1	Function already active.
	412	(ln)	-1	Ill-formed actual parameter list.
	413	(ln)	-1	Too many active functions.
	414	(ln)	-1	Illegal MVAL encounted.
	415	(ln)	-1	Invalid function.
	416	(ln)	-1	Illegal function parameter separator, (,) expected.
	417	(ln)	-1	Post function already active.
	418	(ln)	-1	Illegal MCHAN encountered.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
BUS	501	0	-1	Unrecognizable bus command.
	502	0	-1	End of command not found (! missing).
	503	0	-1	Input line too long.
	504	0	-1	Cannot load PROG or DEFN (running stored program).
	505	0	-1	Bad assignment command.
	506	0	-1	Bad LIST command.
	507	0	-1	Bad SEND command.
	508	0	-1	Bad SET TIME$ or SET DATE$ command.
	509	0	-1	Invalid time or date value.
	510	0	-1	Bad ERROR SRQ command.
	511	0	-1	Bad COPEN, CPAUSE, or CCLOSE command.
	512	0	-1	Bad VIEW PROG ERROR command.
	513	0	-1	Cannot CONTinue stored program execution.
	514	0	-1	Cannot START stored program (bad at load).
	515	0	-1	Error in stored program at load.
	516	0	-1	Bad CSINIT command.
STORED PROG	601	(ln)	-1	Unrecognizable stored program statement.
	602	(ln)	-1	End of statement not found (";" missing).
	603	(ln)	-1	Bad DIMension statement.
	604	(ln)	-1	Bad assignment statement.
	605	(ln)	-1	Bad IF-THEN statement.
	606	(ln)	-1	LOOP without AGAIN.
	607	(ln)	-1	AGAIN without LOOP.
	608	(ln)	-1	EXIT without AGAIN.
	609	(ln)	-1	Bad SCAN statement.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
STORED PROG	610	(ln)	-1	Bad MAKE BUFFER statement.
	611	(ln)	-1	Bad POPEN or PCLOSE PROG statement.
	612	(ln)	-1	Bad BUFFER statement.
	613	(ln)	-1	BEGIN without END or unresolved IF-THEN statement.
	614	(ln)	-1	END without BEGIN.
	615	(ln)	-1	LOOP & EXIT level too deep (10 levels max)
	616	(ln)	-1	IF-THEN nesting too deep (10 levels max)
	617	(ln)	-1	Bad WAIT statement.
	618	(ln)	-1	Bad CNTR number.
	619	(ln)	-1	Bad PRINT statement.
	620	(ln)	-1	Bad BAUD rate.
	621	(ln)	-1	Illegal procedure name.
	622	(ln)	-1	CALL to nonexistent PROCedure.
	623	(ln)	-1	Bad PROC statement.
	624	(ln)	-1	PROCedure already defined.
	625	(ln)	-1	RETURN without CALL or interrupt.
	626	(ln)	-1	PROC without BEGIN.
	627	(ln)	-1	PROC after main program.
	628	(ln)	-1	Possibly not enough memory for all interrupt PROCedures.
	629	(ln)	-1	Bad ON statement.
	630	(ln)	-1	Bad OFF statement.
	631	(ln)	-1	Bad PSINIT statement.
	632	(ln)	-1	ELSE without IF.
	633	(ln)	-1	Bad ELSE statement.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

TYPE	NUMBER	PARAMETER #1	PARAMETER #2	DESCRIPTION
DEFN	701	(ln)	-1	Undefined sensor type or sensor parameter name.
	702	(ln)	-1	Definition syntax error, "=" expected.
	703	(ln)	-1	Definition syntax error, "number" expected.
	704	(ln)	-1	Illegal channel range or channel already defined.
	705	(ln)	-1	Definition syntax error, "," or ";" expected.
	707	(ln)	-1	Parameter not compatible with sensor type.
	708	(ln)	-1	Required signal conditioner address missing.
	709	(ln)	-1	Illegal function name, must be a simple variable identifier.
	710	(ln)	-1	Illegal formal parameter, must be a simple variable identifier.
	711	(ln)	-1	Too many formal parameters, maximum of ten allowed.
	712	(ln)	-1	Illegal formal parameter separator, "," expected.
	713	(ln)	-1	Function definition syntax error, ";" expected.
	714	(ln)	-1	Strain SIGCND current limit exceeded.
	715	(ln)	-1	Improper BRCONF number.
	716	(ln)	-1	Required BRCONF parameter missing.
	717	(ln)	-1	Missing excitation parameter, EXVOLT or EXCUR.
	718	(ln)	-1	Missing STIMFS parameter.
	719	(ln)	-1	Missing XDUCFS parameter.

(ln = line number; cn = channel number; bn = buffer number; pn = port number)

Appendix D

ASCII Codes

ACK	Acknowledge	MSA	My Secondary Address
ASCII	American Standard Code for Information Interchange	MTA	My Talk Address
		NAK	Negative Acknowledge
ATN	Attention	NDAC	Not Data Accepted
BEL	Bell	NRFD	Not Ready For Data
BS	Backspace	NUL	Null
CAN	Cancel	OSA	Other Secondary Address
CR	Carriage Return	OTA	Other Talk Address
DCL	Device Clear	PCG	Primary Command Group
DCn	Device Control 1, 2, 3, or 4	PPC	Parallel Poll Configure
DEL	Delete	PPD	Parallel Poll Disable
DIOn	Data Input/Output 1 through 8	PPE	Parallel Poll Enable
DLE	Data Link Escape	PPRn	Parallel Poll Response 1 through 8
ENQ	Enquiry	PPU	Parallel Poll Unconfigure
EOF	End of File	REN	Remote Enable
EOI	End or Indentify	RS	Record Separator
EOT	End of Transmission	SDC	Selected Device Clear
ESC	Escape	SI	Shift In
ETB	End of Transmission Block	SO	Shift Out
ETX	End of Text	SOH	Start of Heading
FF	Form Feed	SP	Space
GET	Group Execute Trigger	SPD	Serial Poll Disable
GND	Ground	SPE	Serial Poll Enable
GTL	Go To Local	SRQ	Service Request
HT	Horizontal Tab	STB	Status Byte
IEEE	Institute of Electrical and Electronic Engineers	STX	Start of Text
		TCT	Take Control
IFC	Interface Clear	UNL	Unlisten
LF	Line Feed	UNT	Untalk
LLO	Local Lockout	US	Unit Separator
MLA	My Listen Address		

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE	
NUL	0	000	00	0000 0000			ADDRESSED COMMANDS
SQH	1	001	01	0000 0001		GTL	
STX	2	002	02	0000 0010			
ETX	3	003	03	0000 0011			
EOT	4	004	04	0000 0100		SDC	
ENQ	5	005	05	0000 0101		PPC	
ACK	6	006	06	0000 0110			
BELL	7	007	07	0000 0111			
BS	8	010	08	0000 1000		GET	
HT	9	011	09	0000 1001		TCT	
LF	10	012	0A	0000 1010			
VT	11	013	0B	0000 1011			
FF	12	014	0C	0000 1100			
CR	13	015	0D	0000 1101			
SO	14	016	0E	0000 1110			
SI	15	017	0F	0000 1111			
DLE	16	020	10	0001 0000			UNIVERSAL COMMANDS
DC1	17	021	11	0001 0001		LLO	
DC2	18	022	12	0001 0010			
DC3	19	023	13	0001 0011			
DC4	20	024	14	0001 0100		DCL	
NAK	21	025	15	0001 0101		PPU	
SYN	22	026	16	0001 0110			
ETB	23	027	17	0001 0111			
CAN	24	030	18	0001 1000		SPE	
EM	25	031	19	0001 1001		SPD	
SUB	26	032	1A	0001 1010			
ESC	27	033	1B	0001 1011			
FS	28	034	1C	0001 1100			
GS	29	035	1D	0001 1101			
RS	30	036	1E	0001 1110			
US	31	037	1F	0001 1111			

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE	
SPACE	32	040	20	0010 0000	0	MLA	LISTEN ADDRESSES
!	33	041	21	0010 0001	1	MLA	
"	34	042	22	0010 0010	2	MLA	
#	35	043	23	0010 0011	3	MLA	
$	36	044	24	0010 0100	4	MLA	
%	37	045	25	0010 0101	5	MLA	
&	38	046	26	0010 0110	6	MLA	
'	39	047	27	0010 0111	7	MLA	
(	40	050	28	0010 1000	8	MLA	
)	41	051	29	0010 1001	9	MLA	
*	42	052	2A	0010 1010	10	MLA	
+	43	053	2B	0010 1011	11	MLA	
,	44	054	2C	0010 1100	12	MLA	
-	45	055	2D	0010 1101	13	MLA	
.	46	056	2E	0010 1110	14	MLA	
/	47	057	2F	0010 1111	15	MLA	
0	48	060	30	0011 0000	16	MLA	
1	49	061	31	0011 0001	17	MLA	
2	50	062	32	0011 0010	18	MLA	
3	51	063	33	0011 0011	19	MLA	
4	52	064	34	0011 0100	20	MLA	
5	53	065	35	0011 0101	21	MLA	
6	54	066	36	0011 0110	22	MLA	
7	55	067	37	0011 0111	23	MLA	
8	56	070	38	0011 1000	24	MLA	
9	57	071	39	0011 1001	25	MLA	
:	58	072	3A	0011 1010	26	MLA	
;	59	073	3B	0011 1011	27	MLA	
<	60	074	3C	0011 1100	28	MLA	
=	61	075	3D	0011 1101	29	MLA	
>	62	076	3E	0011 1110	30	MLA	
?	63	077	3F	0011 1111		UNL	

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE	
@	64	100	40	0100 0000	0	MTA	TALK ADDRESSES
A	65	101	41	0100 0001	1	MTA	
B	66	102	42	0100 0010	2	MTA	
C	67	103	43	0100 0011	3	MTA	
D	68	104	44	0100 0100	4	MTA	
E	69	105	45	0100 0101	5	MTA	
F	70	106	46	0100 0110	6	MTA	
G	71	107	47	0100 0111	7	MTA	
H	72	110	48	0100 1000	8	MTA	
I	73	111	49	0100 1001	9	MTA	
J	74	112	4A	0100 1010	10	MTA	
K	75	113	4B	0100 1011	11	MTA	
L	76	114	4C	0100 1100	12	MTA	
M	77	115	4D	0100 1101	13	MTA	
N	78	116	4E	0100 1110	14	MTA	
O	79	117	4F	0100 1111	15	MTA	
P	80	120	50	0101 0000	16	MTA	
Q	81	121	51	0101 0001	17	MTA	
R	82	122	52	0101 0010	18	MTA	
S	83	123	53	0101 0011	19	MTA	
T	84	124	54	0101 0100	20	MTA	
U	85	125	55	0101 0101	21	MTA	
V	86	126	56	0101 0110	22	MTA	
W	87	127	57	0101 0111	23	MTA	
X	88	130	58	0101 1000	24	MTA	
Y	89	131	59	0101 1001	25	MTA	
Z	90	132	5A	0101 1010	26	MTA	
[	91	133	5B	0101 1011	27	MTA	
\	92	134	5C	0101 1100	28	MTA	
]	93	135	5D	0101 1101	29	MTA	
^	94	136	5E	0101 1110	30	MTA	
_	95	137	5F	0101 1111		UNT	

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE	
	96	140	60	0110 0000	0	MSA	SECONDARY ADDRESSES
a	97	141	61	0110 0001	1	MSA	
b	98	142	62	0110 0010	2	MSA	
c	99	143	63	0110 0011	3	MSA	
d	100	144	64	0110 0100	4	MSA	
e	101	145	65	0110 0101	5	MSA	
f	102	146	66	0110 0110	6	MSA	
g	103	147	67	0110 0111	7	MSA	
h	104	150	68	0110 1000	8	MSA	
i	105	151	69	0110 1001	9	MSA	
j	106	152	6A	0110 1010	10	MSA	
k	107	153	6B	0110 1011	11	MSA	
l	108	154	6C	0110 1100	12	MSA	
m	109	155	6D	0110 1101	13	MSA	
n	110	156	6E	0110 1110	14	MSA	
o	111	157	6F	0110 1111	15	MSA	
p	112	160	70	0111 0000	16	MSA	
q	113	161	71	0111 0001	17	MSA	
r	114	162	72	0111 0010	18	MSA	
s	115	163	73	0111 0011	19	MSA	
t	116	164	74	0111 0100	20	MSA	
u	117	165	75	0111 0101	21	MSA	
v	118	166	76	0111 0110	22	MSA	
w	119	167	77	0111 0111	23	MSA	
x	120	170	78	0111 1000	24	MSA	
y	121	171	79	0111 1001	25	MSA	
z	122	172	7A	0111 1010	26	MSA	
{	123	173	7B	0111 1011	27	MSA	
|	124	174	7C	0111 1100	28	MSA	
}	125	175	7D	0111 1101	29	MSA	
~	126	176	7E	0111 1110	30	MSA	
	127	177	7F	0111 1111			

Appendix E

Glossary

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a/d converter

Analog-to-Digital Converter. A circuit used to convert information in analog form (such as voltage or current measurements) into digital form.

ACK

Acknowledge; ASCII code 6. Affirmative response to a sender. See also NAK, ACK/NAK transmission.

ACK/NAK transmission

When a blocked format communications protocol is being used, some means must be provided for re-transmission of a block if an error occurs in transmission. The receiver may signal the sender with an acknowledgment (ACK) of error-free receipt or a negative acknowledgment (NAK) indicating error detection.

ADC

See a/d converter.

address

A coded number representing the location of an item. Examples include bus address and program I/O channel.

analog

The representation of numerical quantities which do not have discrete values but which are continuously variable. Electrical measurements are analog in nature until converted into digital signals by an a/d converter. See digital.

ANSI

American National Standards Institute; An industry supported U.S. organization that primarily serves to coordinate and publish technical standards requested by its members.

application program

A program for performing specific functions in a working environment. See program.

arithmetic expression

An equation with arithmetic operators producing a numerical result.

arithmetic operator

A process to be applied to numerical values in an equation (+,-,/, etc.)

array

A group of numbers sharing the same variable name, followed by a subscript.

ASCII

American Standard Code for Information Interchange; ASCII is a standardized code set of 128 characters, including upper and lower case alphabet, numerals, and a set of control characters (line feed, carriage return, etc.)

asynchronous data

Or, "character framed data." A method of transmission transmitting data in which each transmitted character is preceded by a start bit and followed by a stop bit (thus permitting the interval between characters to vary). See synchronous data transmission.

asynchronous I/O

Input or output that occurs independently of other processor operations, at possibly random times. See also synchronous I/O.

autorange

The mode in which an electronic measuring instrument automatically selects the lowest range suitable for an incoming signal.

BASIC

Beginner's All-purpose Symbolic Instruction Code; BASIC is a general purpose, high-level computer programming language developed by Dartmouth College. Because it is versatile and easily learned, BASIC has become widely accepted. Fluke 1722A BASIC has additional commands for instrument control.

baud

Originally used to express the capabilities of a telegraph transmission facility in terms of "modulation rate per unit of time." For practical purposes, it is now used interchangeably with "bits per second" as a unit of measure for data flow.

BCC

Block Check Character; sent from the transmitting station as part of the message block only when a Blocked Format with Block Check Protocol is being used. It is a longitudinal parity check character for the whole message block.

BCD

Binary Coded Decimal; BCD is a digital data format in which each digit of a decimal (base 10) number is represented in order, by its binary equivalent. For example, the decimal number 597 is represented as (0101 1001 0111) in BCD. See binary.

binary

The base two number system; binary numbers are made up of ones and zeros. The least significant digit represents one, the next digit represents twos, the next digit represents fours, and so on with each digit of the binary number corresponding to the next higher exponent of two. See also BCD.

bit

The smallest element of a binary number; a bit (contraction of "binary digit") either represents a high or a low state (one or zero, also mark or space).

blocked format

A data communications protocol which separates messages into blocks, each of which begins with the STY character and ends with the ETX character. The receiving station must either positively acknowledge (ACK) or negatively acknowledge (NAK) each block as it is received. If the block is negatively acknowledged, the transmitter must retransmit the same block again. Additional error detection capability is provided by including a Block Check Character (BCC) immediately following the ETX.

Boolean Algebra

The algebra of logic; deals only with true and false states, used in digital electronics. The basic operators are AND and OR, their inverses, NAND and NOR, and NOT. See also logical operator.

bootstrap

A short program permanently recorded in ROM, whose only function is to read an operating program from bulk storage into system memory and transfer control to it.

bridge

In a measuring system, an instrument in which part or all of its circuit measures one or more electrical quantities. In a 2400B system, quarter-, half-, and full-bridge strain gauges can be used. See microstrain, strain gauge.

buffer

A temporary RAM storage area for data.

bus

A set of parallel connections between instruments. For example, the 2400B can use the IEEE-488-1978 instrumentation bus; a standardized parallel interconnection system for instruments in a measurement and control system. See also IEEE-488 Bus.

Bus Address

A seven-bit code placed on the IEEE-488 Bus to identify an instrument on the bus, and define it as a Talker or Listener.

Bus Command

A series of ASCII characters that, when received by the 2400B over the communication interface, cause an action to be taken by the instrument.

byte

A group of consecutive bits treated as a single entity. A byte is most often considered to be eight bits, which can represent one ASCII character or two numerals. Byte can also mean the storage area needed to hold one eight-bit character.

CALL

A program instruction common to many programming languages, that instructs a computer to "call" (get and use) another section of program code.

CCITT

Comite Consulatif International Telegraphic et Telephonique; an international organization concerned with devising and proposing standards for international telecommunications.

CD

Carrier Detect; RS-232-C, line 8. This signal is sent by DCE to tell DTE that a suitable carrier is present at the DCE. See also DTE, DCE.

channel definition

See definition statement.

character format

The bit structure of one character in a serial communication scheme. Using the Serial Interface (Option 2400B-001), each character is made up of one start bit, seven or eight data bits (the ASCII character), an optional parity bit, and one or two stop bits.

character string

Any collection of characters not intended to have a numerical value. Names, telephone numbers, and Zip Codes are common examples of character strings. See also string, string variable.

common mode

Signals that have the same amplitude and frequency.

computer front end

What the 2400B is: a link between the physical world and a computer. Since the 2400B is programmable and has computational ability, it is capable of sharing part of the entire system load.

computer program

A set of statements recorded into a computer's memory that tell the computer to do a task. Without a program, a computer does nothing.

conditional interrupt

Synchronization of 2400B stored program operation with a certain time of day (ON TIME), time interval (ON CNTR), manually keyed entry (ON KEY), or error occurrence (ON ERROR).

control codes

The first thirty-two ASCII codes, designated for control purposes, such as Carriage Return and Line Feed.

Controller

A device connected to an IEEE-488 bus that is capable of designating instruments as Talkers or Listeners.

Counter/Totalizer

The 2400B option that measures period, frequency, interval, and total event occurrences.

CPU

Central Processing Unit; the controlling instruction and data processor in a computer. In the 2400B, the CPU communicates indirectly with all other assemblies throughout the system through the internal bus structure, and directly to peripheral devices through external communications ports (serial or IEEE-488).

CR

Carriage Return, ASCII code 13; return to the beginning of the current line.

CTS

Clear to Send; RS-232-C line 5. Sent by DCE to DTE when it is ready to accept data. See also DCE, DTE.

current shunt

Traditionally, a precision, low-value resistor placed across an ammeter's terminals to increase its range. The 2400B uses a current shunt resistor in the input circuitry of each channel of the current input connector (Option 2400A-106). The shunt resistor allows the current input to develop a voltage which the 2400B Analog to Digital Converter can measure.

data

Numerical information that has been collected for interpretation by a program.

DAV

Data Valid; an IEEE-488 bus handshake signal, bus line 6. Indicates reception of acceptable data. See also handshake, NDAC, NRFD.

DCE

Data Communication Equipment; the RS-232-C term for computer equipment that sends or receives data. Modems are examples of DCE. The other type of computer equipment specified by RS-232 is DTE, Data Terminal Equipment.

DCL

Device Clear, IEEE-488 Universal Command, ASCII code 20. This message, from the Controller, causes all instruments on the bus to reset the IEEE-488 interface of each instrument on the bus to a known state. The action taken by each instrument is unique for that instrument.

debugging

The process of finding and correcting errors in a computer program.

default

The value or state selected by system software (or firmware) when the user does not specify one.

definition statement

A 2400B statement defining all parameters regarding incoming signals on an input or output channel, determining units and linearization processing to be used.

delimiter

A character that sets the beginning and end of a string, and is not considered to be a part of the string. The four delimiter characters allowed by the 2400B are: ', ", %, or @.

DEOT (DLE EOT)

The 2400B mandatory disconnect character. When the host computer sends DEOT to the 2400B, it causes the 2400B to un-address itself or (when using modems) to disconnect the telephone line.

device

A hardware system resource that can be a source or destination of data. See also system.

digital

A circuit or device concerned only with high or low states (or pulses), generating a logical or numerical result. Digital computers, calculators, and digital watches use digital circuitry. See analog.

dimension statement

Must be entered before array variables can be written to or read. In the 2400B, when an array variable is accessed, the subscript value is checked to see if it falls within the boundaries of the dimension statement. See also array.

DLE

Data Link Escape; ASCII code 16. Depending on the application, DLE may change the meaning of the character(s) that follow, or may indicate another control function. See also EOT.

DSR

Data Set Ready; RS-232-C line 6. Indicator from DCE to DTE that a suitable line connection has been made, that all preliminary line protocol is complete, and that it is ready for data transfer. See also DCE, DTE.

DTE

Data Terminal Equipment; the RS-232-C Standard term for computer equipment where digital information originates or terminates. The 2400B and other computers are examples of DTE. The other type of computer equipment specified by RS-232-C is DCE, Data Communication Equipment.

DTR

Data Terminal Ready; RS-232-C line 20. Sent by DTE to DCE when it is ready to transfer data.

EIA

Electronic Industries Association; the organization that devises electrical and data communication standards including RS-232-C and RS-422.

ENQ

Enquiry; ASCII code 5. A request for re-transmission of the last character sent, from the transmitting station to the receiving station, when it receives no response, or an unexpected response (not ACK or NAK). See ACK/NAK protocol.

EOF

End of File. In the 1722A, this is the character CTRL/Z, ASCII code 26.

EOI

End Or Identify, IEEE-488 bus line 5. Often used by a Talker to designate the end of a data transfer sequence.

EOL

End Of Line; a line termination character that is most often the line feed character or the carriage return character.

EOT

End Of Transmission; ASCII code 4. Used in a serial communications protocol.

EPROM

Erasable Programmable Read Only Memory; EPROMs are Read Only Memories (ROMs) that can be programmed like PROMs with a PROM programmer, but can also be erased by exposure to high intensity ultraviolet light, and then re-programmed.

ESC

Escape; ASCII code 27. Redefines one or more following characters.

ETX

End of Text; ASCII code 3. In a blocked format communications protocol, terminates text that was started by STX.

expression

A combination of variables, constants, numbers, or function references, separated by operators and parentheses in such a way that the whole can be reduced to a single result. See also arithmetic expression, logical expression, relational expression.

firmware

Computer programs recorded in Read Only Memory (see ROM, PROM, EPROM).

flag

A condition or status change indicator that may be checked by a program, and used as a basis for decision.

floating point

A numerical notation useful for computer calculations. In the 2400B, the resolution of a floating point number is 7 digits, and its range is up to 38 places either side of the decimal. When the decimal point is out of range of the displayed digits, the number is displayed in exponential form (E+mn or E-mn, where mn represents the number of places the decimal point must be moved; + for right and - for left). See also floating point variable, integer variable.

floating

A variable A variable used to store and manipulate floating point numeric information. All variables in the 2400B are the floating point type. Floating point variables are represented in Fluke BASIC by a letter followed by either another letter or a number. Examples: A, C9, TX. See also floating point, integer, integer variable.

flowchart

A computer programmer's tool for determining a sequence of operations, using symbols, directional marks, and other representations, showing steps of computer operation. A flowchart is to a computer program what a block diagram is to a circuit schematic.

FORTRAN

Formula Translator; FORTRAN is a computer programming language developed by the IBM Corporation for use on scientific problems. FORTRAN is a popular engineering and technical computer language.

function

A way of performing an operation in the 2400B. There are five classes of functions in the 2400B: Mathematical Functions, Data Formatting Functions, Measurement Functions, Control Functions, and User Defined Functions. See the Quick Reference Guide for details of these functions.

frequency

The cycles-per-second (Hertz) of ac signal. Can be measured in a 2400B system using the Counter/Totalizer Option (2400A-113).

gate inputs

On the Counter/Totalizer assembly (Option 2400A-113), the two gate inputs are used in various ways, including to enable or disable totalization and to measure the period of the combination of two signals.

gauge factor

A strain gauge parameter, gauge factor specifies the characteristics of the strain gauge material being used. In the 2400B, gauge factor is the number specified in a definition statement using the reserved identifier, GAGEFC. A default value of 2.0 is used for GAGEFC if no value is specified in the strain gauge definition statement.

GND

Ground; RS-232-C line 1. A chassis connection intended for the cable shield. Not to be used for signal reference.

GPIB

General Purpose Interface Bus. This is a commonly used name for the IEEE-488 instrument interconnection bus.

handshake

The three-wire hardware protocol used to exchange data on the IEEE-488 Bus. Three bus lines (DAV, NRFD, NDAC) coordinate sending and receiving of data.

hardware

All the electrical, electronic and mechanical components of a computer system. See software.

hexadecimal

The base 16 number system commonly used by computers; 16 digits are represented by numerals 1 through 9, and the letters A through F. Hexadecimal numbers can represent very large decimal numbers with fewer digits.

high level language

A programming language that requires conversion through an interpreter or compiler into machine code before it can be used by a computer. A high level language is similar to human conversational language, and machine code is not. BASIC and FORTRAN are examples of high level languages.

host computer

Can be an IEEE-488 Bus instrument controller, or a computer with a serial port, depending on which interface option used with the 2400B. The host computer interfaces with the 2400B and the user interfaces with the computer for communication.

IC

Integrated Circuit; the name for a semiconductor device containing several discrete components in the same package; constructed on a wafer of semiconductor material such as silicon; usually housed in a Dual In-line Package (DIP).

identifier

In the 2400B, a group of up to six characters that can be used in a Bus Command, definition statement, or stored program statement. An identifier is either user-assigned or reserved. See also reserved identifier.

IEEE

Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, NY 10017. The IEEE is the publisher of Standard IEEE-488-1978, for interconnection of electronic instruments.

IEEE-488 Bus

A parallel bus system agreed upon by participating instrument manufacturers for interconnecting instruments to form a system.

IFC

Interface Clear; IEEE-488 Bus line 9. Set high by the controller to reset the IEEE-488 interface of each instrument on the bus to a known state. The action taken by each instrument on the bus is unique for that instrument.

Immediate Mode

The mode in which commands entered into the 2400B through the host computer cause immediate action in the 2400B. See Bus Commands.

integer

An exact whole number. Compared to floating point numbers, integers have a more limited range (-32768 to 32767 in Fluke BASIC), but normally process faster and require less storage space. See also integer variable, floating point.

integer variable

A representation of an exact whole number. Integer variables are normally used for event counting, and for comparisons where exactness is required. See also integer, floating-point variable.

interface

A hardware and software connection of a device to a system. For example, either the Serial Interface or the IEEE-488 Interface must be used to connect a host computer to the 2400B.

interference

The presence of undesirable energy in a circuit, caused by electrostatically or electromagnetically coupled external circuits.

interpreter

An executive routine that, as the computation progresses, translates a stored program in some machine-like pseudo-code into machine code and performs the indicated operations as they are translated. The 2400B stored program language is executed by an interpreter.

interrupt

In the 2400B, a process where the stored program suspends its current operation in response to a random event such as the reception of key input from a serial port, detection of change of state on an Interrupt Input channel, arrival to a certain preset time, or expiration of a specified interval.

interrupt procedure

A special type of user defined procedure; activated by an interrupt instead of a CALL statement. Interrupt procedures have a dedicated name that must be used when defining: INT(x), where x is the interrupt number. See also user defined procedure, interrupt, CALL.

I/O

Input/Output.

isothermal

Means an area of equal temperature. The 2400B Thermocouple Input Connector (Option 2400A-102) uses an alloy isothermal terminal block to stabilize and equalize input lead temperatures.

K byte

Kilobyte, or 1024 bytes. K, the abbreviation for kilo, normally means to multiply by 1000, but when used to describe digital electronic memory size or locations in byte units, means to multiply by the power of two nearest to 1000 (1024).

LF

Line Feed; ASCII code 10. Move to the next line. Usually preceded by CR. See also CR.

Listener

IEEE-488 bus device designated by a Controller to receive data or instructions from a designated Talker or controller. There can be more than one Listener on a bus at the same time.

logical expression

An expression that can contain variables, constants, and function references, and is separated by logical operators and parentheses, yielding a logical result (true or false).

logical operator

A function that compares, selects, or matches. In the 2400B, the logical operators are AND, OR, and NOT. These are used for Boolean operation. See also Boolean Algebra.

LSI

Large Scale Integration; the achievement of building a large amount of circuitry onto one small chip. LSI chips are monolithic integrated circuits, typically containing the equivalent of two hundred to several thousand simple logic circuits.

machine code

The coded bit-patterns of directly executable machine-dependent computer instructions, represented by numbers or binary patterns.

main memory

The RAM from which a computer directly executes all instructions. The main memory is used for fast, intermediate storage of data or programs.

mainframe

The central part of the computer containing the Central Processing Unit (CPU).

microprocessor

A principle component of a microcomputer; an integrated circuit CPU that contains an arithmetic unit, a logic unit, and usually a programmable instruction set memory.

microstrain

The unit of strain measured by a strain gauge in a 2400B system.

MLA

My Listen Address; IEEE-488 Bus Listen Address. ASCII codes 32 through 62 correspond to MLA 0 to MLA 30, respectively. Each instrument on the bus must have a unique Listen Address. See also MTA.

modem

A transmitter and receiver of digital data. One modem receives data from an attached computer terminal and sends the data on a modulated carrier signal to another modem. The other modem demodulates the received carrier and sends the recovered data to another computer terminal.

motherboard

The printed circuit board onto which other circuit boards in the 2400B are plugged.

MTA

My Talk Address; IEEE-488 Talk Address. ASCII codes 64 through 94 correspond to MTA 0 to MLA 30, respectively. Each instrument on the bus must have a unique Talk Address. See also MLA.

NAK

Negative Acknowledge; ASCII code 21. Negative response to a sender. See also ACK, ACK/NAK Transmission.

NDAC

Not Data Accepted; IEEE-488 handshake signal, bus line 8. Held high by each Listener until the current data byte is accepted. Only when all Listeners on the bus have released NDAC will it go low. See also DAV, handshake, NRFD.

NRFD

Not Ready For Data; IEEE-488 handshake signal, bus line 7. Held high by each Listener until it is ready to receive a data byte. Only when all listeners on the bus have released NRFD will it go low. See also DAV, handshake, NDAC.

NUL

Null; ASCII code 0. A fill character consisting of zero bits.

null modem

An adapter cable that allows two pieces of DTE to communicate without the need for modems (DCE) when used in a direct-connect RS-232-C network. See also DTE, modem, DCE.

offset resistor

A resistor, either fixed or variable, connected in series with a Resistance Output assembly (Options 2400A-305 and 2400A-306) to obtain a higher output range. The value of the offset resistor is added to the Resistance Output.

operator

A term for symbols within an application program (such as + or <) that identify operations to be performed. Also see arithmetic operator, logical operator.

overrange

The state indicated by a measurement instrument when an input signal is greater (or lower) than the range that the instrument can measure.

parallel data

The system where each bit is sent on a separate line. The IEEE-488 Bus transfers parallel data. See also serial data.

parallel port

An external connection through which parallel data is transferred. The IEEE-488 port on the 2400B IEEE Interface Option (2400B-002) is a parallel port. See serial port.

parity

A method of error detection that uses one extra bit for each unit of information (such as a character). The parity bit is set to one or zero so that the total number of one-bits in the byte is even or odd, depending on the type of parity in use.

pcb

Printed circuit board. Electronic components are mounted on, and soldered to, this flat sheet of non-conductive material, with circuit patterns "printed" on its surface as metallic runs.

PDL

Program Design Language; a shorthand notation for describing the structure of a program. See also pseudo-code.

Poisson's ratio

A strain gauge parameter; the ratio of the lateral strain to the longitudinal strain in a specimen subjected to a longitudinal stress. In a 2400B system, the value of Poisson's ratio is assigned via the reserved identifier, PRATIO, in the strain gauge definition statement. The default value for PRATIO is 0.2.

port

A connection point used for data transfer. See interface.

post function

A special 2400B user defined function for data conversion, executed whenever a channel is read by a measurement function, if reference to that function was included in the definition statement.

procedure

A subroutine within a 2400B stored program; executed when called by a CALL statement in the program. See CALL.

program

A sequence of computer instructions that cause a system to accomplish a desired task.

programming language

A vocabulary of words and characters used to compose computer programs. A programming language can be a high-level (similar to human conversational) language like BASIC or FORTRAN, or a low-level language (machine code). See also high level language, machine code, program.

PROM

Programmable Read Only Memory; a memory IC that can be recorded by an equipment manufacturer using specialized equipment.

protective ground

The common chassis ground that is connected to earth ground through the ground wire in the line power cord. See also signal ground.

protocol

A set of rules for exchange of information between a system and a device or between two systems. In data communications, a protocol defines the rules for electrical, physical, and functional characteristics of the communications link. Such a protocol contains the control procedures required to facilitate data transfer across the link interfaces. When using the 2400B-001 Serial Interface, all protocol selections are made by setting the switches and jumpers on the interface.

pseudo-code

A representation of a program, not directly executable by a computer. A program represented by pseudo-code must be translated into a form which the target computer can execute. See also PDL.

RAM

Random Access Memory. Through common usage, the term has come to mean the high-speed volatile semiconductor memory that is normally used for system and user memory.

real time clock

A clock in the 2400B that is set to time of day for use whenever required by system software.

REC

Received Data, RS-232-C line 3. This line carries the stream of serial data from DCE to DTE. See also serial data, DCE, DTE.

relational expression

An expression containing variables, constants, numbers, and function references, separated by relational operators and parenthesis in such a way that the whole can be reduced to a single (true or false) result. See also relational operator.

relational operator

An operator that compares the relative value of one variable, constant, number, or expression, with another variable, constant, number or expression. Examples of relational operators are "=", "<", and ">=". See also operator, relational expression.

reserved identifiers

Identifiers that have special meaning to the 2400B, and may not be used as user-assigned variables. Reserved identifiers include system variables and functions.

RET

Return; RS-232-C line 7. A signal return line that serves as a zero voltage reference point for all other signals.

RFI

Radio Frequency Interference; see interference.

ROM

Read Only Memory; digital circuitry used for permanently recorded computer programs and data.

RS-232-C

A digital communications standard agreed upon by participating manufacturers of data communication equipment for the transfer of serial digital data between data communication equipment (DCE) and data terminal equipment (DTE). The 2400B is a DTE device. The standard is published and maintained by the Electronic Industries Association, 2001 Eye Street, N.w., Washington, D.C. 20006. See also DCE, DTE, serial data.

RTD

Resistance Temperature Detector; a device with a resistance that varies predictably with changes in temperature. Made of various materials, with platinum the most popular and accurate.

RTS

Request To Send; RS-232-C line 4. The signal from DTE to DCE when it has data to transmit. See also DTE, DCE.

scanner

An option in the 2400B system that allows the computer in the 2400B to select a desired analog input channel for measurement. Available are the High Performance Scanner (three-wire, 2400A-101), Four-Wire Scanner (2400A-115), and Six-Wire Scanner (2400A-117).

SDC

Selective Device Clear; IEEE-488 Addressed Command, ASCII code 4. From the controller, this command causes the addressed Talker or Listener to reset to some defined state. The action taken by the device is unique to that instrument.

serial data

Information transmitted one bit at a time over a single line at a predefined bit rate (baud). See also baud.

serial poll

A method of sequentially determining which instrument on an IEEE-488 bus has requested service. One instrument at a time is checked through the eight data lines.

serial port

A connection point on a computer that is used to transfer information in a serial manner. Data transmission through a serial port in the 2400B is in the form of asynchronous ASCII codes.

shield input

The input lead on various 2400B options that can be grounded or connected to the low lead at a measurement point to reduce interference. The shield input is attached to the braided shield wire surrounding the conductor in the cable.

signal ground

A conductor establishing electrical ground reference potential for all transmitting circuits in a communications network.

software

Computer programs and data recorded on and read from memory that can be erased and rewritten. See firmware, hardware.

SRQ

Service Request; IEEE-488 bus line 10. This line allows a Talker or Listener (such as the 2400B) to interrupt the host computer when ever necessary.

statement

One line or step in a computer program.

status

An open or closed state of a switch, or a high or low logic level. The 2400B system has options for Status Input (2400A-104) and Status Output (2400A-301).

stepper motor

A motor that normally moves in discrete uniform steps of angular motion, powered by control pulses. The 2400B Stepper Motor Controller is Option 2400A-307.

stop bit

Using the Serial Interface (Option 2400B-001), the stop bit follows the transmission of the data bits (the ASCII character), and the parity bit (if used), to signify the end of the character.

stored program

The computer program loaded into 2400B RAM through a host computer that allows the 2400B to carry out measurement and control functions independently of the host.

strain gauge

A resistive transducer the electrical output of which is proportional to the amount it is deformed under stress or strain. Strain gauge circuits use fixed precision resistors and resistors bonded to a surface to be mechanically loaded, in quarter-, half-, or full-bridge configuration. See also bridge, gauge factor, microstrain.

string

A series of characters enclosed by two matching delimiter characters. Delimiter characters allowed by the 2400B are: ', ", %, or @. The delimiter characters are not considered to be part of the string.

string variable

A variable that represents a collection of characters that may or may not be numeric.

STX

Start of Text; ASCII code 2. See also ETX, Blocked Format.

subroutine

A section of a program that performs a specific function on request of the main program or another subroutine. Called a "procedure" in the 2400B. See procedure.

synchronous data transmission

Or "message framed data;" where digital information is transmitted in predetermined message block sizes, with start and stop characters sent at the beginning and end of a message, and the characters of the message sent contiguously. See asynchronous data.

syntax

The proper grammar required for an interpreter to recognize and execute a program statement.

syntax diagram

A pictorial representation of the grammar required for the execution of a program statement.

system

Any interconnection of hardware and software devices that cooperate to accomplish a task. In an IEEE-488 instrumentation system, a Controller is an essential part of the system whenever the designations of Talkers and Listeners needs to be changed during the task. A controller or host computer is a necessary part of any system that requires data processing or a centralized control point.

system variables

Reserved identifiers that have special functions in the 2400B. Although some system variables have subscripts, it is not necessary to dimension them, because the 2400B reserves space for them automatically.

Talker

An IEEE-488 connected instrument that has been designated by the Controller on the bus to send data to Listeners.

thermocouple

A pair of dissimilar conductors joined together, forming form a junction that generates a voltage when the opposite conductors are at different temperatures. The 2400B has provisions for 12 different types of thermocouples (using the Thermocouple Input Connector, Option 2400A-102).

transducer

A device that converts energy from one form to another. An example of a transducer is a strain gauge.

UART

Universal Asynchronous Receiver/Transmitter. The LSI component used in a serial interface to convert between internal parallel data format and external serial data format. See also LSI, RS-232-C, parallel data, serial data.

user defined function

A user-created mathematical function that has a unique name and can be used in a stored program.

user defined procedure

A procedure created by the user that can be executed by a CALL statement in a stored program.

user memory

Area reserved in main memory for storage and execution of user-written application programs and data.

variable

A representation of a quantity, or the quantity itself, which can assume any of a given set of values.

volatile memory

A form of memory that loses its contents when its supply voltage is shut off. See also RAM.

XMT

Transmitted Data, RS-232-C line 2. The line that carries the stream of serial data from DTE to DCE. See also RS-232-C, serial data, DCE, DTE.

X-OFF

CTRL/S or DC3 ASCII code (decimal 19); sent by the receiving station to halt transmission from the sending station when information is coming too fast for the receiver to process. When able to receive more information, the receiving station sends X-ON to restart the transmitting station. See also X-ON.

X-ON

CTRL/Q or DC1 ASCII code (decimal 17); sent by the receiving station to cause the transmitting station to resume transmission of data after being halted by an X-OFF command. See also X-OFF.

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